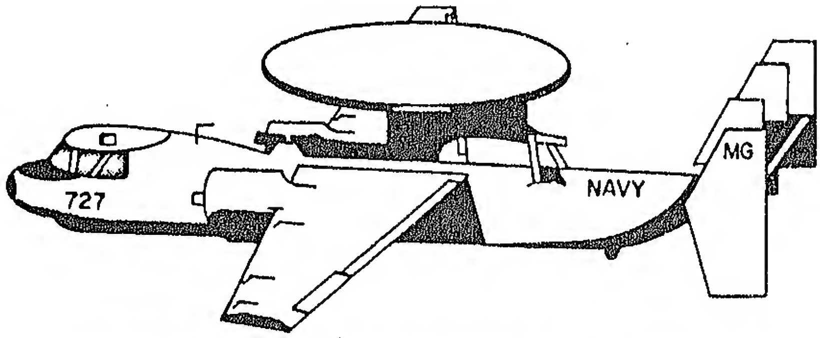
STUDENT'S STUDY GUIDE AND WORKBOOK

FOR

AVIATION ELECTRICIAN'S MATE COURSE

CLASS A1

C-602-2012



AIRCRAFT ELECTRICAL SYSTEMS

UNIT 6

CNTT-M1089

Rev 7-82

PREPARED BY

NAVAL AIR TECHNICAL TRAINING CENTER
NAVAL AIR STATION MEMPHIS
MILLINGTON, TENNESSEE

PREPARED FOR

NAVAL TECHNICAL TRAINING COMMAND

FOREWORD

As a result of a study conducted in the fleet over the last several years, Naval Technical Training Courses have moved in the direction of increased "hands-on" training in order to make training more job-relevant. Innovative teaching methods have been implemented to improve training and increase efficiency.

This guide reflects the results of increased "hands-on" training in the form of laboratory assignments which the student will utilize in performing the specified learning tasks. The guide includes other materials, such as study guides, information sheets, data sheets, work sheets, and self-test items.

Your future success in the Navy will depend on how effectively you grasp the information presented in this guide and the other material provided during this course of training. The investment you make now in learning will pay big dividends in the fleet and in your future life.

TRAINING OFFICER
AE(A1) SCHOOL

TABLE OF CONTENTS

WORK SHEETS PAGE NO.

SAFETY NOTICE

The AE should always use the proper tools for the job being accomplished, observing the safety precautions for that tool or tools.

The AE must consider all circuits to be energized at all times; this will prevent accidental electrical shock.

When using a voltmeter, the AE must always observe proper polarity to prevent damage to the meter.

When using an ohmmeter, the AE must always remember to remove power from the circuit and to isolate the circuit to achieve the proper readings.

Protective clothing shall be worn, and safety equipment used, as the situation warrants. All personnel working with electrical circuits will avoid wearing loose clothing, rings, watches, and other metallic objects.

All control switches should be in the OFF position prior to energizing an electrical circuit. Then, all work accomplished on energized circuits must be monitored by an instructor.

HOW TO USE THE STUDENT'S GUIDE

In this Study Guide and Workbook, you will find the following materials.

Lesson topic learning objectives for each lesson topic.

Study guides for each lesson topic designed for note taking.

Information sheets containing supplemental information or information not readily available in references.

Laboratory assignments and data sheets.

Criterion self-tests.

These materials are designed to aid you in attaining the stated objectives. Complete the book as neatly and accurately as possible and review it for preparation to take progress tests and performance tests.

TERMINAL AND MAJOR ENABLING OBJECTIVES

Upon completion of this unit of instruction, you will have completed in part the following objectives:

4.0 MAINTAIN under supervision, representative Aircraft Electrical, Electronic, and Instrument systems in accordance with applicable job plan/maintenance instruction manual.

4.3 PERFORM operational check of representative Aircraft Navigational Instrument systems consisting of Magnetic Compass, Attitude and Heading Reference System and True Airspeed using a job plan checklist on a training device selected to provide efficient training. This check requires accomplishment of each step in the correct sequence and without error.

4.4 PERFORM operational check of representative Aircraft Engine Instrument systems consisting of Oil Pressure, Fuel Pressure, Fuel Flow, Engine Temperature and Engine RPM using a job plan checklist on a training device selected to provide efficient training. This check requires accomplishment of each step in the correct sequence and without error.

4.5 PERFORM operational check of representative Aircraft Equipment Instrument systems consisting of Fuel Quantity, Hydraulic Pressure and Position Indicator (Landing Gear, Speed Brake, Flap) using a job plan checklist on a training device selected to provide efficient training. This check requires accomplishment of each step in the correct sequence and without error.

NOTE: All objectives cannot be accomplished until requested training devices have been received.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the factors that affect capacitance.

2. SELECT from a list the formula for capacitive reactance.

3. MATCH conditions of the basic capacitance bridge circuit to the correct statement.

4. LABEL the components of a bridge circuit as applied to a capacitance fuel quantity system.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 391-393

OUTLINE:

1. Review of factors affecting capacitance

   a. Plate area

   b. Distance between the plates

   c. Dielectric

2. Review of capacitance in an a.c. circuit.

3. Simple capacitance bridge circuit

   a. Operation

   b. As applied to fuel quantity systems

4. Function

TITLE: Capacitor-Type Fuel Quantity Indicating System

REFERENCE: Handbook, Operation and Service Instructions, Minneapolis, Honeywell, AN 05-65AA-9

PRINCIPLES OF OPERATION: Capacitance Fuel Quantity System

The capacitance fuel quantity system is an electronic fuel-measuring device that indicates fuel quantity in pounds. Basically, the system consists of one or more tank units, power unit, and indicator that constitute a rebalancing capacitance bridge circuit. A change in the fuel quantity in the fuel tank causes a change in tank unit capacitance, which, in turn, unbalances the capacitance bridge circuit. The voltage signal, resulting from the unbalanced bridge condition, is amplified by a phase-sensitive amplifier in the power unit which energizes one winding of a miniature two-phase induction motor in the indicator unit. The induction motor drives the wiper of a rebalancing potentiometer in the proper direction to restore the bridge to a balanced (null) condition and simultaneously positions an indicator pointer to read the quantity of fuel remaining in the fuel tank.

The capacitance of any capacitor depends upon three factors: the area of the plates; the distance between the plates; and the material between the plates (the dielectric). Since the tank unit is rigidly constructed, the first two factors are always constant. Therefore, the capacitance of the tank unit can be varied only by changes in the dielectric. When such a capacitor is placed vertically in a fuel tank which is partly full, its dielectric is composed of fuel and air. Since the dielectric constant of fuel is approximately twice that of air, the capacitance of the tank unit is about twice as great when the fuel tank is full as when the fuel tank is empty. Any change in fuel quantity between "empty" and "full" produces a corresponding change of capacitance.

NOTE: See figure 1.

The capacitance of the tank unit is accurately measured by means of a capacitance bridge circuit. In this circuit, the tank unit capacitance to be measured is compared to a reference capacitors of known value. The tank unit and reference capacitance are connected in series across a transformer winding. A center tap from the winding is brought to point "P" between the tank unit and the reference capacitor. If the tank unit and reference capacitor have equal values and the center tap divides the impressed voltage equally, the voltage drop across each capacitor is the same and equals half the voltage impressed by the transformer. Therefore, the current in the tank unit leg of the bridge is equal to the current in the reference leg. Since the path between the center tap and point "P" is common to both currents and since the currents flow in opposite directions through this path, the resultant current between the center tap and point "P" is zero, and the bridge is balanced.

As the quantity of fuel in the fuel tank increases, the capacitance of the tank unit increases, resulting in a greater flow of current in the tank unit leg of the bridge. The resultant current, flowing between the center tap and point "P", is equal to the difference between the current in the tank unit leg and the current in the reference leg, and the bridge is no longer balanced. The voltage signal, applied across the center tap and point "P", is in phase with that of the tank unit side of the circuit. If the quantity of fuel in the tank decreases, the capacitance of the tank unit also decreases, resulting in a smaller flow of current in the tank unit leg of the bridge. The resultant current between the center tap and point "P" will flow in the opposite direction, and the phase relationship will be reversed.

In practice, a two-stage amplifier connected between point "P" and ground, amplifies any signal resulting from an unbalanced bridge. The amplifier output, which bears the same phase relationship as the input signal, excites the variable phase winding of a two-phase indicator motor. The fixed phase winding on the indicator motor is constantly energized from a tap on the power unit transformer primary, with the voltage shifted 90 electrical degrees by a fixed capacitor. As a result, the indicator motor is phase-sensitive, that is, it will operate in either direction, depending upon whether the tank unit capacitance is increasing or decreasing.

As capacitance in the tank unit side of the bridge increases or decreases, because of a change in fuel quantity, it is necessary to reapportion the voltage drop across the reference capacitor accordingly to maintain continuous bridge balance. This is accomplished by the rebalancing potentiometer connected across one end of the transformer secondary and in series with the reference capacitor. The indicator motor drives the potentiometer wiper in the direction necessary to maintain continuous balance.

An empty adjustment potentiometer and a full adjustment potentiometer are connected across portions of the winding at opposite ends of the transformer secondary. These potentiometers furnish a means of adjusting bridge voltages to balance the empty to full capacitance range of a specific system.

The amplifier is not part of the measuring circuit. Therefore, the accuracy of the system is independent of vacuum tube characteristics, and tubes can be replaced without affecting calibration of the system. Since the system is continuously balancing and operates at the "null" point, it is independent of normal voltage and frequency variations in the power supply.

In situations where the tanks consist of a number of cells, or are irregular in shape, two or more tank units are installed. By proper selection of the location of these tank units, it is possible to minimize the effects of changes in aircraft attitudes and of sloshing of fuel in the tanks. When two or more tank units are used in a single tank, they are connected in parallel so that their capacitances are added, and the total capacitance is representative of the quantity of fuel in the tank.

NOTE: See figure 2.

The capacitance-type fuel quantity system is practically unresponsive to volumetric changes resulting from variation in temperature. The effect of an increase in temperature on fuel is twofold. It results in a thermal expansion which raises the level of fuel between the tubes of the tank unit, but it also reduces the dielectric constant of the fuel. These two effects serve to counterbalance one another, and the capacitance per pound of fuel remains nearly constant over the temperature range ordinarily encountered by military aircraft, as shown by the gage response in figure 2. This results in a more accurate indication of actual fuel quantity, since the energy available from the fuel depends on weight rather than volume.

As indicated in figure 2, the change in dielectric constant is greater than the change in density, to a small extent. This is true whether the change in density is due to temperature variations, as illustrated, or due to difference between fuels. In the case of aircraft using more than one type of fuel, as jet aircraft, or in cases where the error due to temperature change of approximately 2% is excessive, a method of correction has been devised. A special tank unit, the compensator, supplies sufficient correction to the reference capacitance to make the amount of error due to dielectric variations negligible.

The compensator is mounted at the lowest level of usable fuel in the tank. Its electrical connections are such that the capacitance is in parallel with that of the reference capacitor.

Since neither electrode of the tank unit is grounded and since one of the leads between the tank unit and the amplifier is shielded, the capacitance to ground does not enter into the circuit. Therefore, the length of the tank unit leads does not affect the accuracy of the system, and the power unit may be located wherever it is protected from the weather and accessible for servicing.

The test switch is used to unbalance the bridge circuit momentarily when system operation is to be checked. When the switch is closed, voltage is reduced on the tank unit side of the bridge, greatly unbalancing the circuit. As a result, the indicator drives toward the empty end of the dial. Opening the switch should restore the bridge to balance and return the indicator pointer to its original position. This response by the indicator proves that the system is operating normally.

The indicator includes, as a secondary function, either a high or low-level switch or a transmitting potentiometer.

A warning switch consists of a wiper isolated from the contact plate by an adjustable insulator. The insulator on a low-level switch can be adjusted to actuate a warning device at any pointer position from approximate mid-scale to empty. On a high-level switch, adjustment is provided from approximate mid-scale to full. Either type of switch remains closed from the point of actuation to its respective end of scale.

An indicator with a transmitting potentiometer provides a resistance proportional to fuel quantity. This resistance can be used to control a remote device which has a function correlated with, or dependent upon, fuel consumption.

OPERATION INSTRUCTIONS:

When installed in an aircraft, the fuel quantity indicating system's operation is entirely automatic. No special operation instructions are necessary except for an occasional check with the test switch to test system operation.

NOTE: Theory of operation of the liquid oxygen system, is the same as the capacitance fuel quantity system, which will be discussed in the remaining lessons on liquid quantity.

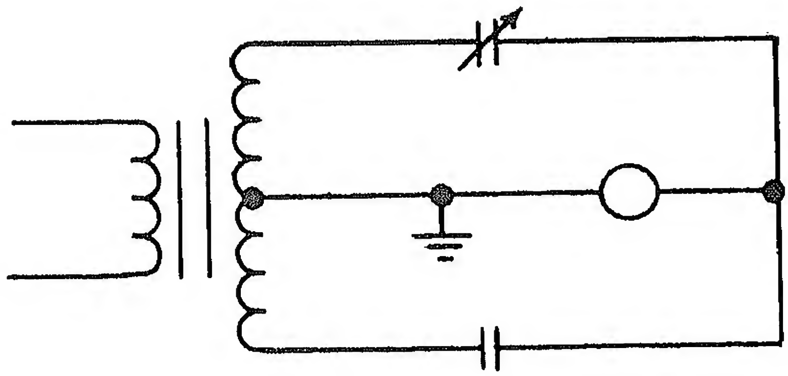


Figure 1

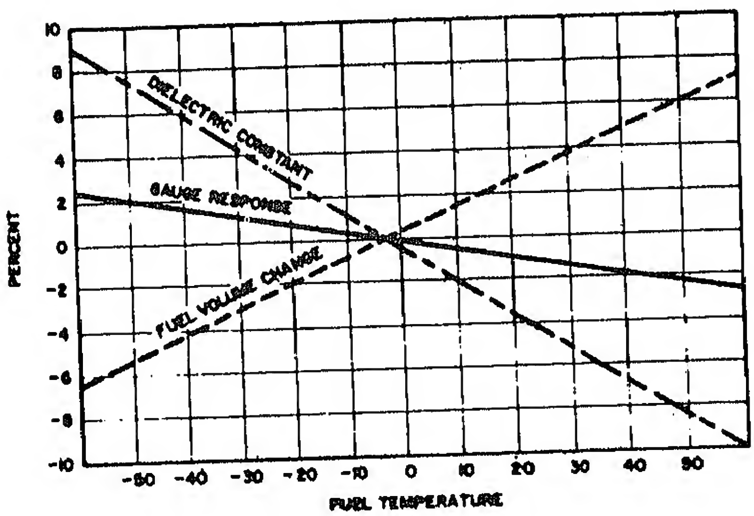


Figure 2

1. Select the factors affecting capacitance.

 a. Plate area, distance between the plates, and capacitive reactance.

 b. Plate area, distance between the plates, and dielectric constant.

 c. Plate area, distance between the plates, and temperature.

 d. Plate area, distance between the plates and frequency.

2. Select the formula for capacitive reactance.

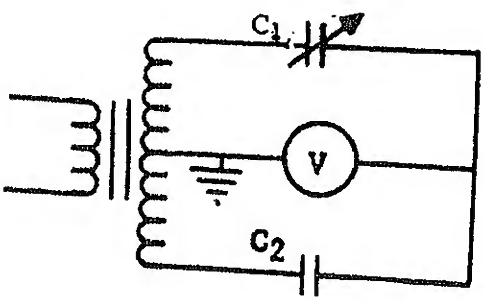
 a. $X_C = 2\pi fc$

 b. $X_C = \frac{1}{2\pi fc}$

 c. $X_C = 2\pi fL$

 d. $X_C = \frac{1}{2\pi fL}$

3. Match the conditions of the simple capacitance bridge circuit listed in Column A below to their correct statement listed in Column B.



Column A

___(1) C1 and C2 have the same capacitance.

___(2) C1 increases in capacitance.

___(3) C1 decreases in capacitance.

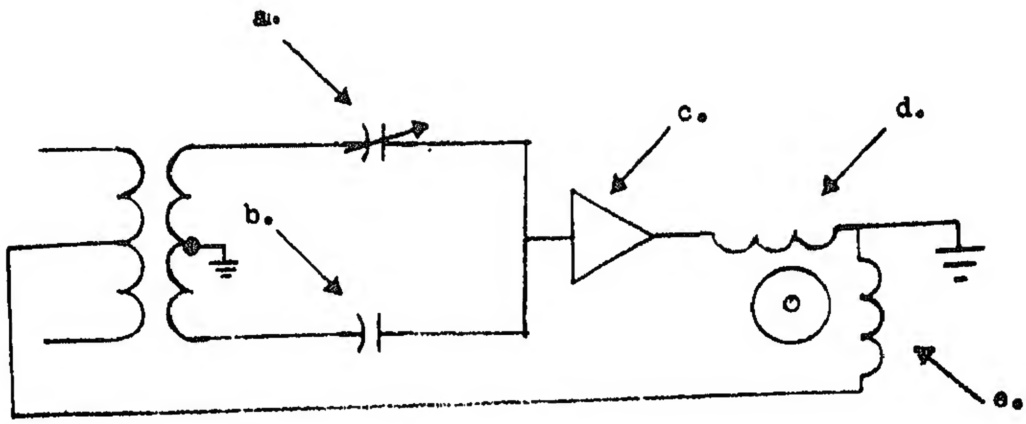
Column B

a. C2 develops smaller signal voltage than C1.

b. No current flow in the center leg.

c. C1 develops smaller signal voltage than C2.

4. Label the components in the fuel quantity circuit below.



_______(1) Fixed phase of two phase induction motor.

_______(2) Amplifier

_______(3) Reference capacitor

_______(4) Variable phase of 2Ø induction motor

_______(5) Tank unit capacitor(s)

1. Of the three factors that affect capacitance, the ______________ is the only variable of the tank unit capacitor in a liquid quantity system.

2. The error signal is developed in a liquid quantity system by ______________ the capacitance bridge circuit.

3. The function of the liquid quantity system is to measure the ______________ in terms of ______________________________.

4. With a decrease of temperature, fuel volume ______________ and its dielectric constant ______________________.

Lesson Topic Learning Objectives: Upon completion of this lesson, the student will be able to, with 100 percent accuracy:

1. SELECT from a list the function of the Tank Unit.
2. SELECT from a list the statements describing construction of the Tank Unit.
3. MATCH capacitance and capacitive reactance of tank unit to fuel level condition.
4. SELECT from a list the function of the Power Unit and Amplifier Section.
5. MATCH each component of the Power Unit and Amplifier Section to its function.
6. SELECT from a list the function of the Indicator.
7. MATCH each component of a fuel quantity indicator to its function.
8. SELECT from a list the statement that describes the compensator unit.
9. SELECT from a list the purpose of the compensator unit.
10. MATCH each statement describing the operation of a fuel quantity bridge circuit to a fuel level condition.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 393-396

OUTLINE:

1. Tank unit

   a. Function

b. Construction

c. Operation
   (1) Fuel level increases

   (2) Fuel level decreases

2. Indicator
   a. Function

   b. Construction
      (1) Unit comparisons

      (2) Components
         (a) Two-phase induction motor

(b) Output shaft

(c) Rebalance potentiometer (R118)

(d) Power unit and amplifier section
<u>1</u>. Function

<u>2</u>. Purpose

<u>3</u>. Components
<u>a</u>. Transformer

1) Primary

2) Secondary

<u>b</u>. Voltage amplifier (V101)
1) Purpose

2) Construction

3) Operation

<u>c</u>. Power Amplifier (V102)
1) Purpose

2) Construction

3) Operation

(e) Calibrating potentiometers (R110 & R114)

1. Purpose

2. Full adjust (R110)

3. Empty adjust (R114)

3. Test switch

a. Purpose

b. Operation

4. Compensator unit

a. Description

b. Purpose

c. Construction

d. Operation

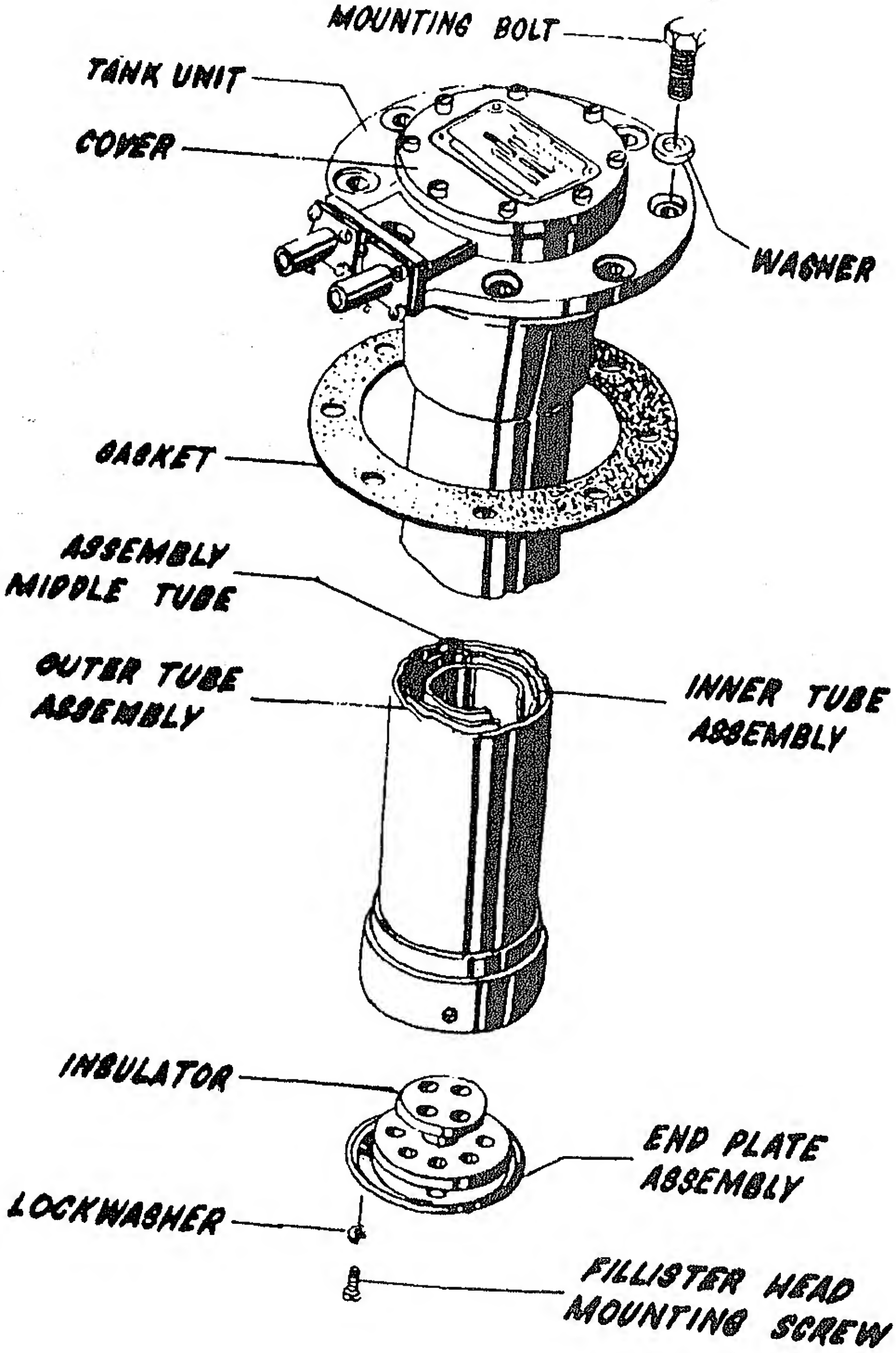
5. Relay control unit
   a. Function

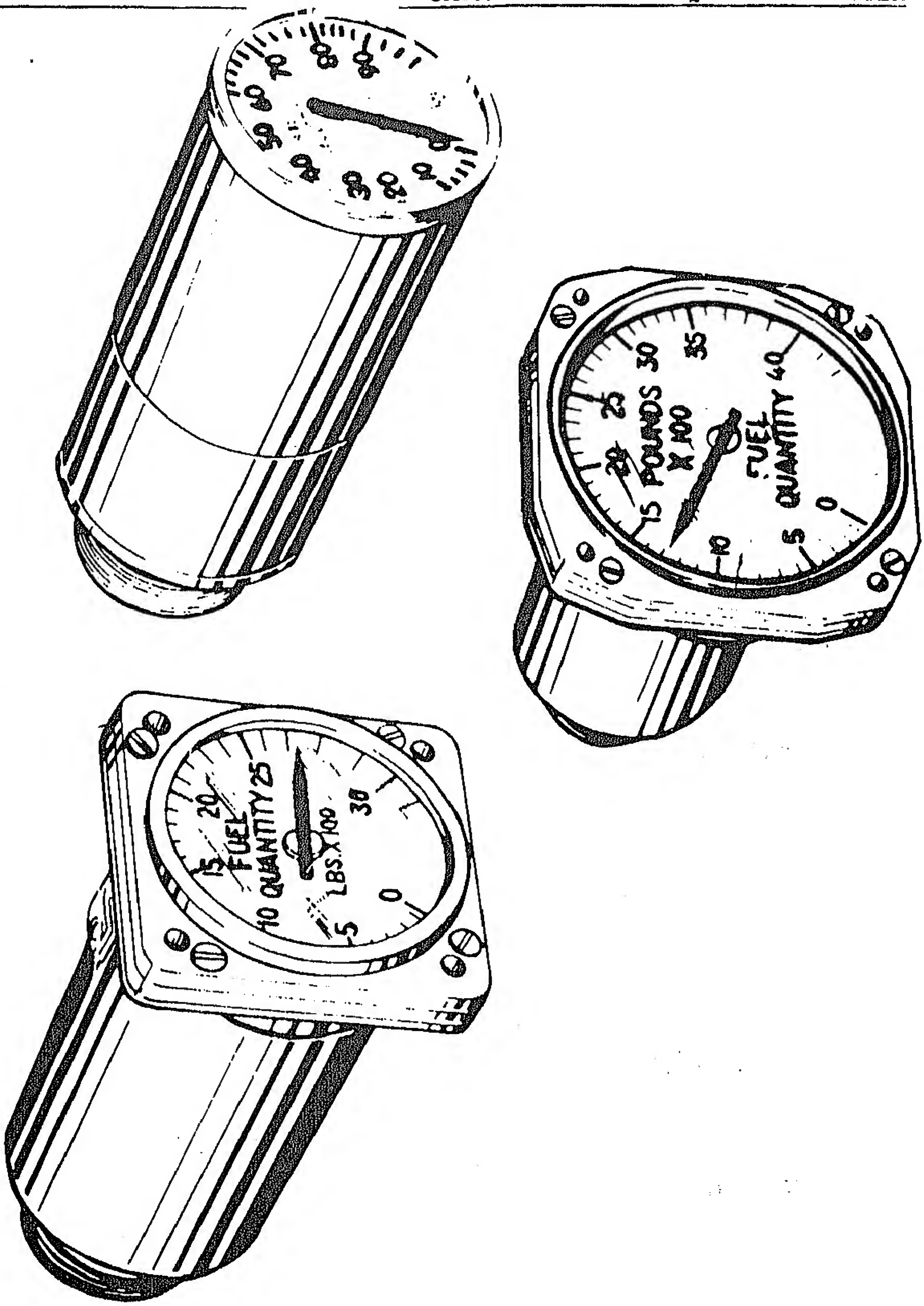
   b. Operation

6. System operation
   a. Fuel level increases

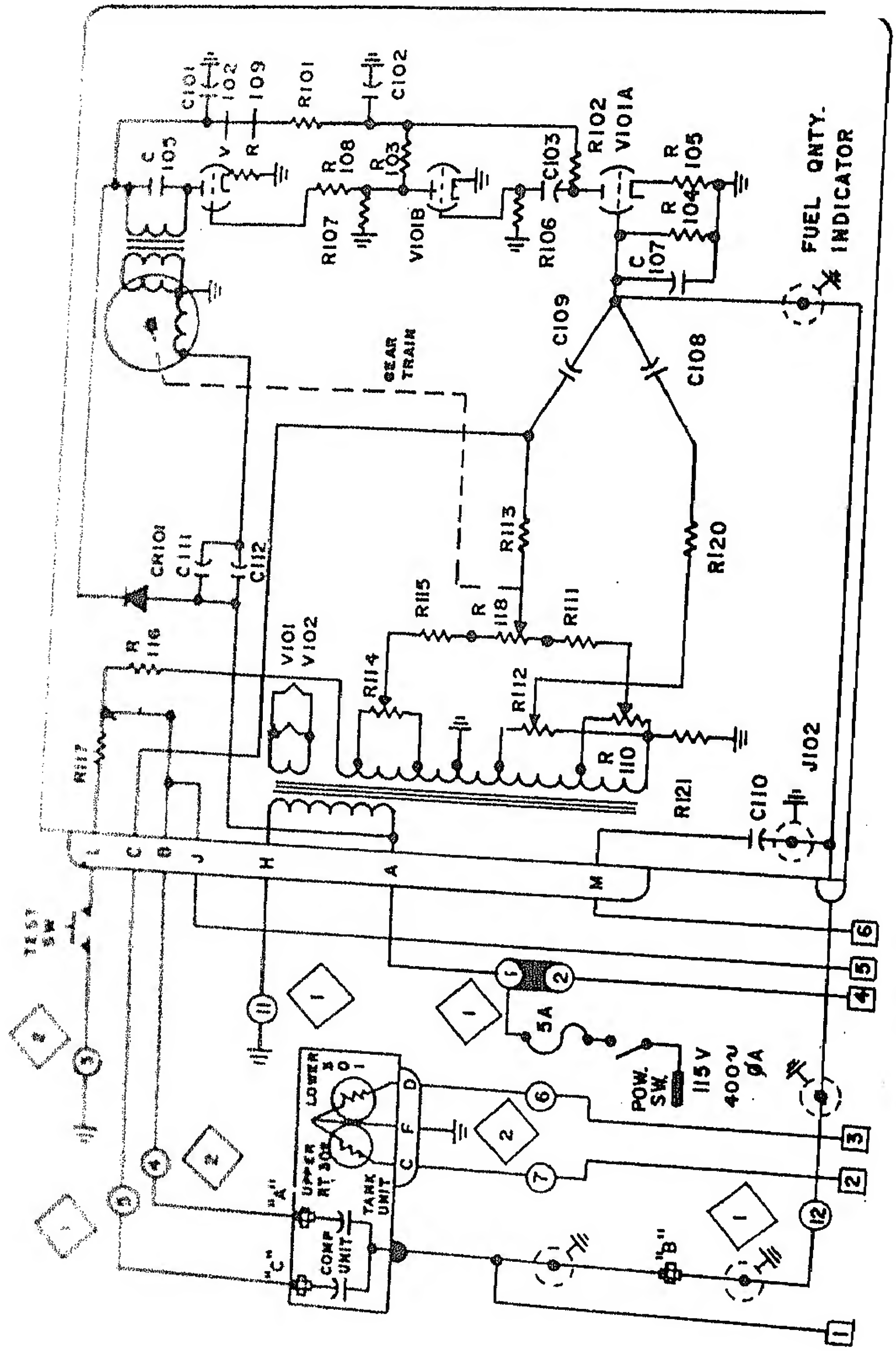
   b. Fuel level decreases

TANK UNIT


MOUNTING BOLT
TANK UNIT
COVER
WASHER
GASKET
ASSEMBLY MIDDLE TUBE
OUTER TUBE ASSEMBLY
INNER TUBE ASSEMBLY
INSULATOR
END PLATE ASSEMBLY
LOCKWASHER
FILLISTER HEAD MOUNTING SCREW

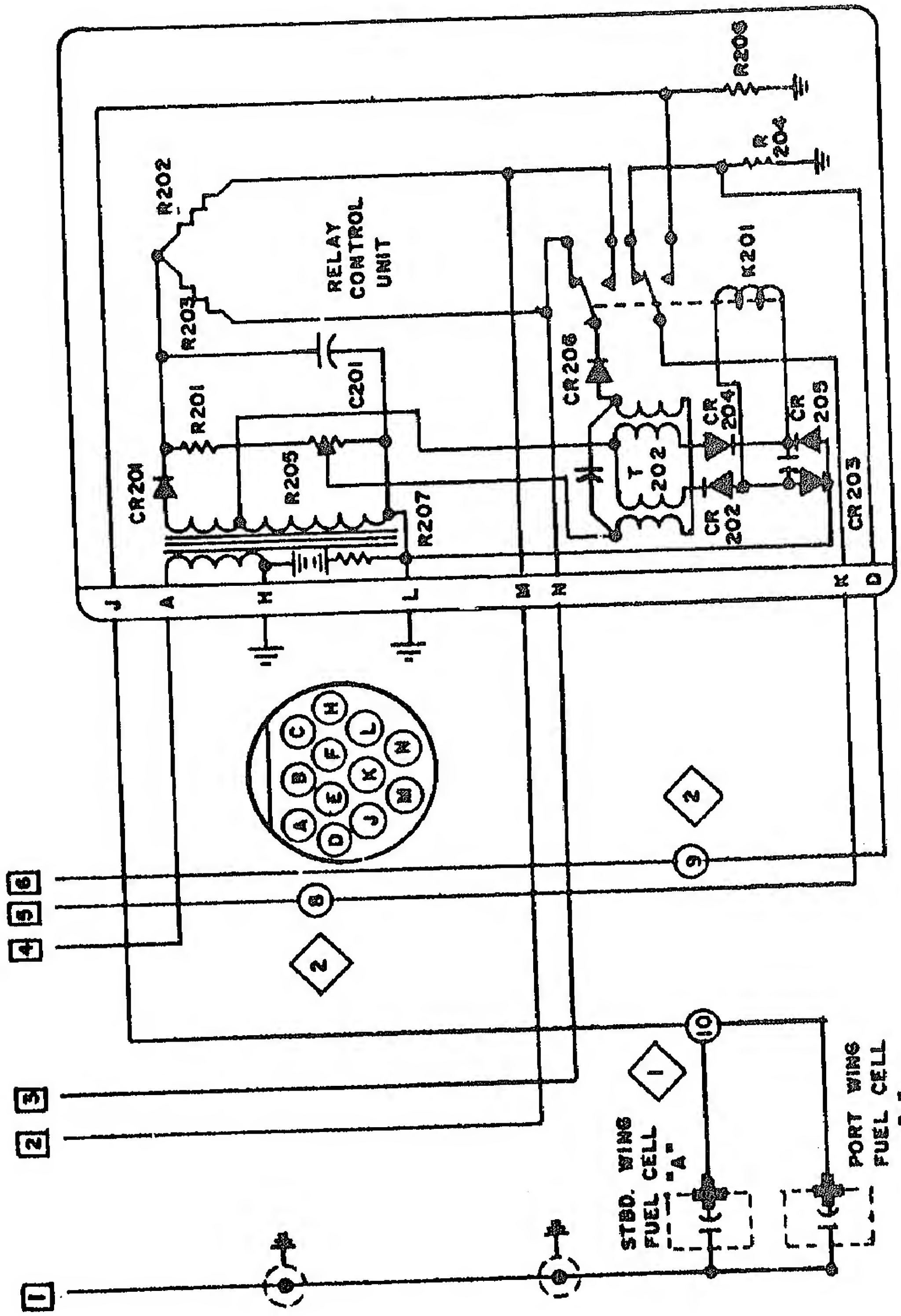


FUEL GAGE INDICATORS



A 4 CAPACITANCE FUEL QUANTITY SYSTEM (SHEET 1)

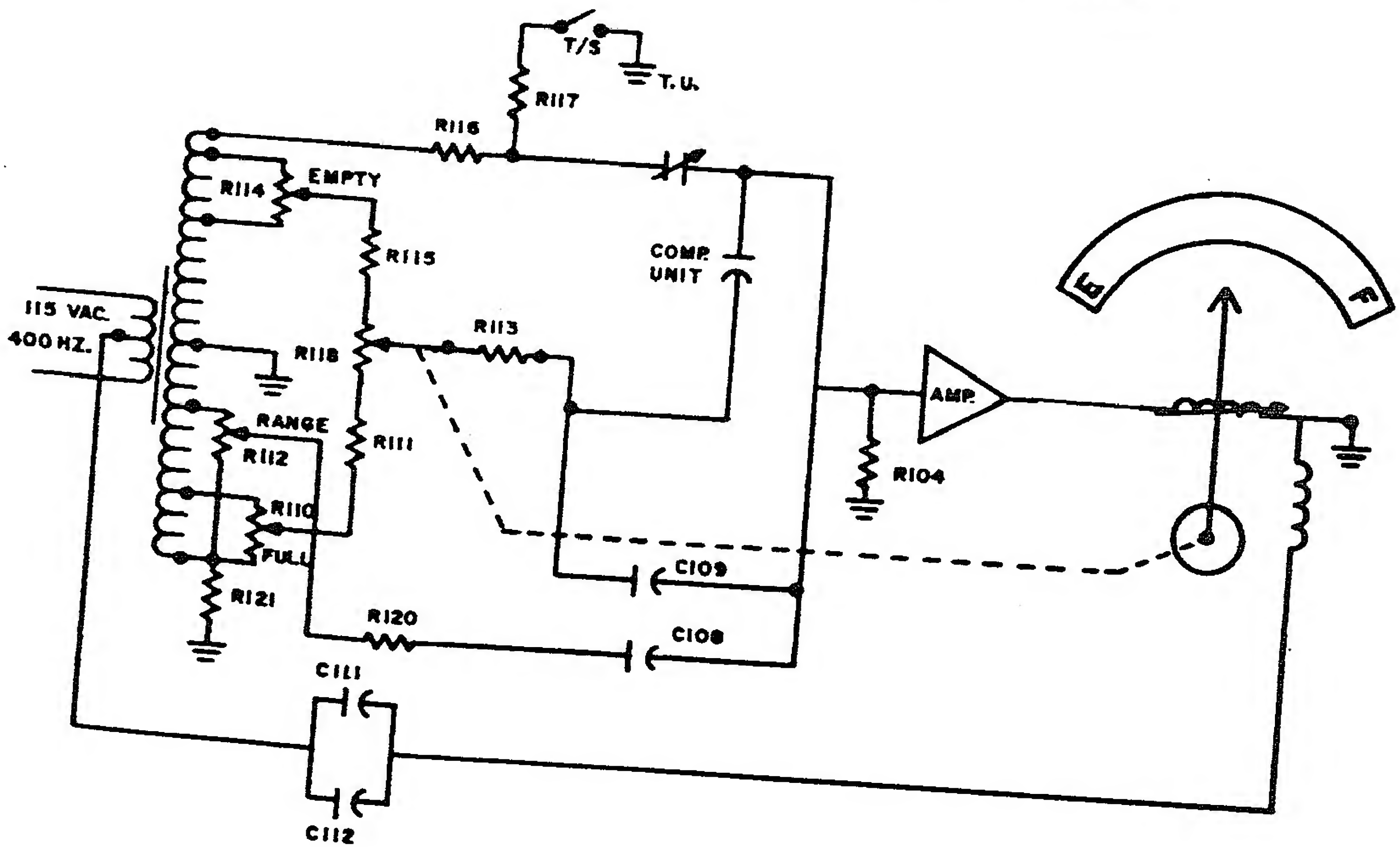
AE-84-75



A4 CAPACATANCE FUEL QUANTITY SYSTEM (SHEET 2)

AE-03-78

A-4 CAPACITANCE FUEL QUANITY SYSTEM



AE-82-75

1. Select the function of a Tank Unit.

   a. A variable capacitor which compensates for changes in fuel density.

   b. A variable capacitor which senses any change in fuel level by a change in its capacitance.

2. Select the statement(s) which describe the construction of a Tank Unit.

   a. Three aluminum tubes having the same diameters.

   b. The two inside tubes form the electrodes of the capacitor.

   c. A fixed capacitor, mounted in the fuel cell.

   d. A variable capacitor, mounted vertically in the fuel cell.

   e. A variable capacitor, whose capacitance changes as fuel level changes.

3. Match the capacitance and capactive reactance of the Tank Unit listed in Column A to the fuel level conditions listed in Column B.

Column A	Column B
___(1) C $\uparrow$	a. Fuel level increases
___(2) C $\downarrow$	b. Fuel level decreases
___(3) $X_C \downarrow$	
___(4) $X_C \uparrow$	

4. Select the function of the power unit and amplifier section.

   a. Amplifies the error signal from the transformer primary.

   b. Amplifies the error signal from the bridge.

5. Match the components of the power unit and amplifier section listed in Column A to their function listed in Column B.

Column A COMPONENTS	Column B FUNCTION
a. Test Switch	___(1) Checks operation of system
b. R118	___(2) Provides two-stage amplification
c. V102	___(3) Provides variable phase excitation to indicator motor.
d. V101	___(4) Balances bridge voltages during calibration
e. R110	
f. R114	

6. Select the function(s) of the indicator.

a. Indicates amount of fuel, in gallons, remaining in fuel cell.

b. Indicates amount of fuel, in pounds, remaining in fuel cell.

7. Match the components of the indicator listed in Column A to their function listed in Column B.

Column A COMPONENTS	Column B FUNCTION
a. C111 & C112	___(1) Reference Capacitor
b. Output shaft	___(2) Rebalances the bridge circuit.
c. Two-phase induction motor	___(3) Maintain a 90^{o} phase relationship between motor phases.
d. R118	___(4) Drives R118 to rebalance bridge circuit.
e. C103 & C104	___(5) Receives variable phase excitation from V102.
f. C109	

8. Select the description(s) of the compensator unit.

   a. Mounted vertically in fuel cell.

   b. Mounted horizontally in fuel cell.

   c. Connected in parallel with reference capacitor.

9. Select the purpose of the Compensator Unit.

   a. Compensates for different reference capacitors.

   b. Compensates for different fuel densities.

10. Match the statements describing operation of the bridge circuit listed in Column A to the fuel level conditions listed in Column B.

Column A	Column B
___(1) Xc of tank unit increases	a. Fuel level increasing
___(2) Xc of tank unit decreases	b. Fuel level decreasing
___(3) C of tank unit increases	
___(4) C of tank unit decreases	
___(5) Current in tank leg decreases	
___(6) Current in tank leg increases	
___(7) Reference leg current increases	
___(8) Reference leg current decreases	

1. The tank unit is a ____________ capacitor, ____________ mounted in the fuel cell that senses any change in ______ ________ by a change in its ________________.

2. When two or more tank units are in the same fuel tank, they are connected in ________________.

3. When fuel level decreases, capacitance of the tank unit ____________, capacitive reactance ___________, and current in the tank unit leg ____________.

4. The indicator gives the pilot a ___________ indication of the amount of fuel in _____________ that is remaining in the tank.

5. The fixed phase of the two-phase induction motor in the indicator is excited from a tap on the ________ ________ and the variable phase is excited by the output of the __________________________.

6. The rebalance potentiometer reblances the bridge by varying the voltage across the ________________ leg.

7. The power unit and amplifier section serves as the _______ _____________ for the system and amplifier of the ______________ signal from the ____________________.

8. The empty adjust (R114), is in the ________ leg and the full adjust (R110), is in the ______________ leg.

9. When the test switch is closed, it ______________ the potential of the ___________ leg, causing the bridge to ________________ and the indicator pointer drive towards ____________________________________.

10. The compensator unit _______________ for changes in _______ constant and ______________ of fuel whether caused by temperature changes or different types of fuel.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the purpose of the MD-1 Tester.

2. MATCH the components of the MD-1 Tester to their functions.

3. WRITE the procedures for calibrating the fuel quantity system in the proper sequence.

4. CALIBRATE a Fuel Quantity System on a training device.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 560-562

OUTLINE:

1. Tester used
   a. Purpose

   b. Components

c. Operation

2. Calibration procedure
   a. Preparation of tester

   b. Empty adjustment

   c. Full adjustment

1. Select the purpose of the MD-1 Tester.

   a. The MD-1 Tester is to be used in calibrating and adjusting the Capacitance Fuel Quantity Indicating System.

   b. The MD-1 Tester is used for testing the tank unit and coaxial and unshielded leads.

2. Match each component of MD-1 Tester listed in Column A to its function listed in Column B.

Column A	Column B
a. Desiccator tube	___(1) Variable capacitor which simulates tank unit capacitance.
b. C_1	___(2) Extends range of capacitance to 6100 uuf.
c. C_2	___(3) Used on systems with compensator.
d. C_3	___(4) Removes moisture from case
e. Correction card	___(5) Allows more accurate calibration

3. Write the procedures for calibrating the Fuel Quantity System listed in Column A in their proper sequence in Column B.

Column A	Column B
	Step
a. Perform empty adjustment	___(1)
b. Perform full adjustment	___(2)
c. Press to test	___(3)
d. Recheck empty setting	___(4)
	___(5)

TIME: Contact Hrs. 0 Minutes 50, Periods 1

EQUIPMENT LIST:

1. Screwdriver
2. Mock-up, Capacitance Fuel Quantity System
3. Tester, Fuel Quantity, Type MD-1

PROCEDURES:

Step 1: Power OFF

Step 2: Connect cables to tester.

SEE NOTE.

Step 3: Empty Adjustment

a. Set compensator capacitance to 25.2 pf, using variable capacitor C_3.
b. Set empty capacitance of 146.8 pf, using variable capacitor C_1.
c. Set range extending capacitor C_2 to zero.
d. Turn power ON.
e. Remove indicator from panel.
f. Set empty (E) adjustment so pointer is positioned at zero graduation.

Step 4: Press test switch momentarily. (Pointer should rotate CCW and return to adjusted position of zero.)

Step 5: Full Adjustment

a. Set compensator capacitance to 57.2 pf. using variable capacitor C_3.
b. Set full capacitance to 325.4 pf, using variable capacitor C_1.
c. Set full (F) adjustment so pointer is positioned at 5800 lbs. on indicator.

Step 6: Press test switch momentarity. (Pointer should rotate CCW and return to adjusted poistion of 5800 lbs.

JS 3.2.3

Step 7: Recheck empty setting. If necessary, recalibrate system using Step 3. Then recheck full setting. If necessary, recalibrate system using Step 5.

Step 8: Have instructor check.

Instructor's initial ________

Step 9: Secure mock-up and equipment when told to do so by the instructor.

Step 10: Safety precautions observed

Instructor's initial ______

NOTE: This is for the compensated system; terminal "C" on the MD-1 will be used.

1. The __________ tester is used to calibrate capacitance fuel quantity systems.

2. On an uncompensated system, terminal __________ on the MD-1 ____________________ used.

3. The __________________ tube removes ____________ from the tester case.

4. The __________ tester can be used for both _______________ and _______________ systems.

5. The variable capacitor (________) is adjustable from __________ to ___________ pf.

WS 3.2.3

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the purposes of the MD-2A tester.

2. MATCH each component of the tester to its function.

3. SELECT from a list statements concerning the operation of the tester.

4. SELECT from a list the power requirements of the tester.

5. SELECT from a list statements concerning testing procedures.

6. TEST a Fuel Quantity System on a training device.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 560-562

OUTLINE:

1. Tester used

   a. Purpose

   b. Components

c. Operation

2. Testing procedure
   a. Preparation of tester

   b. Capacitance test

   c. Resistance test

1. Select the purpose(s) of the MD-2A Tester.

   a. Used to measure unknown capacitance.

   b. Used to calibrate the Capacitance Fuel Quantity System.

   c. Used to test tank unit capacitance.

   d. Used to measure leakage resistance of tank units, coaxial leads, and unshielded leads.

   e. Used to test unknown resistance.

2. Match each component of the tester listed in Column A to its function listed in Column B.

Column A		Column B
a. Indicator (capacitance meter)	____(1)	Enables operator to select pf or megohmmeter
b. Capacitance range selector switch	____(2)	Enables operator to measure leakage resistanc
c. Meg-ohmmeter range selector switch	____(3)	Extends range of capacitance pf meter
d. Operation selector switch	____(4)	Used to read unknown capacitance

3. Select the statement(s) that describe the operation of the Indicator (capacitance pf meter).

   a. Operates on the principle of a self-balancing capacitance bridge circuit.

   b. The fixed phase of the two-phase induction motor receives its excitation from an amplifier.

   c. Operates on the principle of a self-balancing inductance bridge circuit.

4. Select the power requirements for the MD-2A tester.

   a. 110/200 volts a.c. 400 hertz Single phase

   b. 115 volts a.c. 60 hertz Single phase

   c. 115 volts a.c. 400 hertz Single phase

   d. 200 volts a.c. 400 hertz Single phase

5. Select the statement that describes the condition causing continuous rotation of the Indicator (capacitance pf meter).

   a. Unknown resistance greater than 5,000 ohms and cannot be measured.

   b. Unknown capacitance greater than 5,000 pf and cannot be measured.

CT 3.2.4

TIME: Hours 0 Minutes 50, Periods 1

EQUIPMENT LIST:

1. Mock-Up, Fuel Quantity System
2. Tester, Fuel Quantity, Type MD-2A

PROCEDURE:

STEP 1: Capacitance check

a. Make sure power switch is OFF, on the MD-2A tester
b. Connect power cable to tester.
c. Connect tester to "Tank Unit" connectors "A" and "B" with cables provided.
d. Place operation "Selector Switch" to CAPACITANCE uuf position.
e. Place "RANGE Selector Switch" to X_1 position.
f. Turn power switch ON.
g. Allow one minute for tester to warm up.
h. Note the reading on Capacitance Indicator.

NOTE: If the indicator continues to rotate in X_1 Range position, turn the Range Selector Switch to a higher range.

i. Log the reading ________________.
j. Normal reading: 90 to 110pf.
k. Have instructor initial ________________.
l. Turn power switch OFF.

STEP 2: Resistance check

NOTE: Make resistance checks with cables connected to "Tank Unit" connectors.

a. Turn "Selector Switch" to "A to B" position.
b. Place Megohmmeter "Range Selector Switch" to X 1000. Observe megohmmeter reading.
c. Log reading ________________.
d. Minimum resistance: 100,000 megohms.
e. Have instructor initial ________________.
f. Place "Selector Switch" to "A to GND" position. Observe megohmmeter reading.
g. Log reading ________________.
h. Minimum resistance: 30,000 megohms.

i. Have instructor initial ______________.
j. Place "Selector Switch" to "B to GND" position. Observe meg-ohmmeter reading.
k. Log reading ____________________.
l. Minimum resistance: 30,000 megohms.
m. Have instructor initial ______________________.
n. Turn power switch OFF.
o. Disconnect power cable and tank unit cables.
p. Stow cables and secure tester.
q. Safety precautions observed.

Instructor Initials ___________.

1. Warmup time for the MD-2A is ______ ______________________.

2. If capacitance indicator continues to rotate, you should turn " _______ ______________ _____________________" to a higher range.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the type of operational inspection which requires system calibration.

2. MATCH components of the indicator with their functions.

3. MATCH the abnormal indications with the malfunctions to which they pertain, using the system schematic.

4. SELECT from a list the procedures used when analyzing system faults.

5. TROUBLESHOOT Capacitance Fuel Quantity System on a training device.

6. IDENTIFY maintenance action required on Maintenance Action Form.

OUTLINE:

1. Inspections
   a. Visual

   b. Operational

2. Circuit analysis
   a. Normal operation

   b. Malfunctions

3. Review troubleshooting procedure

   a.

   b.

4. Analyze system faults

   a. Check circuit for malfunction

   b. Diagnose cause of malfunction

   c. Detect and isolate fault

1. Select the type of operational inspection which requires system calibration.

   a. Daily

   b. Major

   c. Pre-flight

2. Match components of the indicator listed in Column A to their functions listed in Column B.

Column A COMPONENTS	Column B FUNCTIONS
a. V101	___(1) Provides two stages of amplification
b. V102	___(2) Restores bridge to balanced condition
c. R104	___(3) Provides output to variable phase of 2-phase induction motor.
d. R118	___(4) Signal developing resistor
e. C111 & C112	___(5) Maintain 90° phase shift between fixed and variable phases of 2-phase induction motor.

CT 3.2.5

3. Using the system schematic match the indicated malfunctions listed in Column A to their probable causes listed in Column B.

Column A		Column B
Abnormal Indications		**Malfunctions**
a. No operation	____(1)	Open between TB-1 Terminal 12 and Connector J102 of indicator.
b. Indicator runs CCW continuously	____(2)	Open between Indicator Pin H and TB-1 Terminal 11.
c. Indicator runs CW continuously	____(3)	Open between TB-1 Terminal 5 and Indicator Pin C.
	____(4)	Open between TB-2 Terminal 4 and Connector "A" of Fuselage Cell Tank Unit.
	____(5)	Open between TB-1 Terminal 1 and Indicator Pin A.
	____(6)	Faulty Capacitors C111 & C112.
	____(7)	Open in Resistor R109.
	____(8)	Open in Resistor R104.

4. Select the procedures used when analyzing system faults.

   a. Calibrate system

   b. Check circuit for operation

   c. Isolate the multimeter

   d. Detect and isolate the malfunction

   e. Diagnose causes of malfunction

Work Sheet   Troubleshooting the Capacitance Fuel Quantity System

---

1. On the operational check of the fuel quantity, you allow ______________ __________________warm up time.

2. The most common types of system faults are __________,

   __________________, _______________ and ______________.

3. An open in the signal developing resistor would cause

   _____ _________________________ of the indicator.

WS 3.2.5

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the source of the earth's magnetic field.

2. SELECT from a list the statement which describes the direction of the earth's magnetic field.

3. SELECT from a list the cause(s) of distortion of the earth's magnetic field.

4. SELECT from a list the statement that pertains to lines of force passing through a magnetic material.

5. MATCH the magnetic poles to the statement that describes them.

REFERENCE:

Basic Electricity, NAVPERS 10086-B, Pages 23-25

OUTLINE:

1. Source

2. Lines of force
   a. Characteristics

   b. Effects

3. Magnetic poles
    a. Description

    b. Polarity

    c. Location

4. Application
    a. Reference

    b. Instruments

SG 3.2.6

1. Select the source of the earth's magnetic field.

   a. Mineral deposits on earth's surface
   b. Deposits of lodestone at North & South Pole
   c. Earth's core

2. Select the statement which describes the direction of the earth's magnetic field.

   a. Lines of force leave the South Geographic Pole and enter the North Geographic Pole.

   b. Lines of force leave the North Geographic Pole and enter the South Geographic Pole.

   c. Lines of force leave the South Magnetic Pole and enter the North Magnetic Pole.

   d. Lines of force leave the North Magnetic Pole and enter the South Magnetic Pole.

3. Select the cause(s) of distortion of the earth's magnetic field.

   a. Highly permeable materials in the earth's crust.
   b. Man made structures containing large quantities of highly permeable materials.
   c. Varying atmospheric conditions
   d. Altitude above sea level

4. Select the statement that pertains to lines of force passing through a magnetic material.

   a. Magnetic field strengthened by magnetic materials.
   b. Magnetic field weakened by magnetic materials.
   c. Causes them to become magnetized.
   d. Field does not affect the magnetic material.

5. Match the magnetic poles listed in Column A to the statement that describes them listed in Column B.

Column A	Column B
a. Magnetic North	___(1) Attracts South Pole of a free suspended magnet
b. Magnetic South	___(2) Attracts North Pole of a free suspended magnet
	___(3) Located in Hudson Bay area
	___(4) Located near Antarctic continent

CT 3.2.6

1. The lines of force leave the earth at the pole having what magnetic polarity?

   Answer ______________________________.

2. The lines of force enter the earth at the pole having what magnetic polarity?

   Answer:______________________________.

3. The earth's North Pole has what magnetic polarity?

   Answer: ______________________________.

4. Which magnetic pole lies in the Hudson Bay area of northern Canada?

   Answer: ______________________________.

5. List three causes of distortion in the earth's magnetic field.

   Answer: a. ________________________.

   b. ________________________.

   c. ________________________.

6. Where are the lines of force vertical to the earth's surface?

   Answer: ______________________________.

7. Do lines of force leave the earth at the North Pole?

   Answer ______________________________.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. COMPLETE a statement explaining the purpose of the direct reading magnetic compass.

2. MATCH each component of the direct reading magnetic compass to its function.

3. SELECT from a list statements which describe the compensating device.

4. MATCH each type of compass error listed to its cause.

5. MATCH each type of compass error listed to the method of correction.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 335-336 and 342

OUTLINE:

1. Purpose

2. Components
   a. Float assembly
      (1) Float

      (2) Directive magnets

      (3) Card

b. Case Assembly
   (1) Jewel post

   (2) Bowl

   (3) Expansion unit

   (4) Lubber line

c. Compensating device (Universal type)
   (1) Location

   (2) Components
      (a)

      (b)

   (3) Operation
      (a)

      (b)

3. Operation of Direct Reading Magnetic Compass.
   a.

   b.

4. Variation
   a. Definition
      (1)

      (2)

SG 3.2.7

b. Causes

(1)

(2)

(3)

(4)

c. Correction

(1)

(2)

5. Deviation

a. Definition

b. Causes

(1)

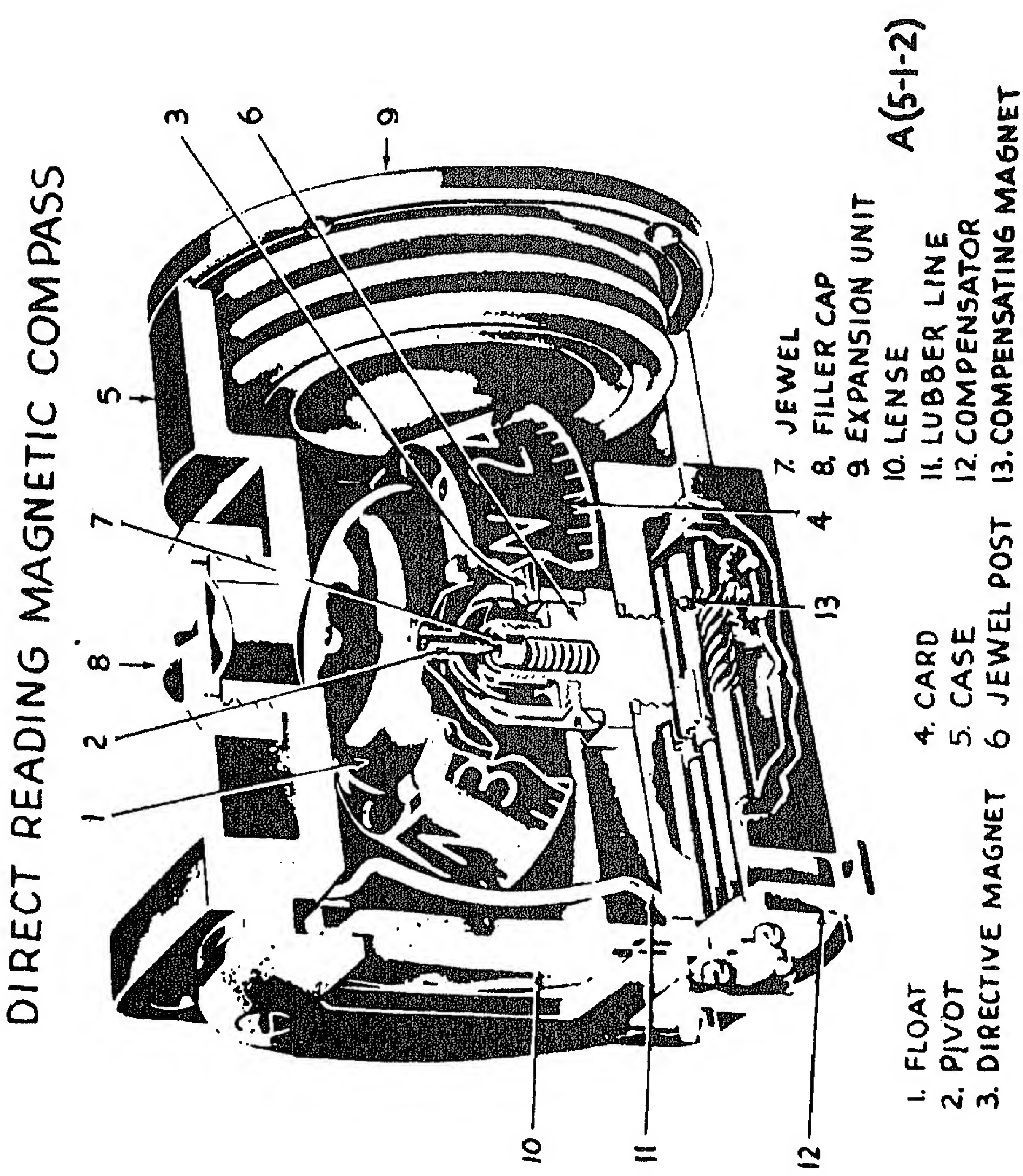
(2)

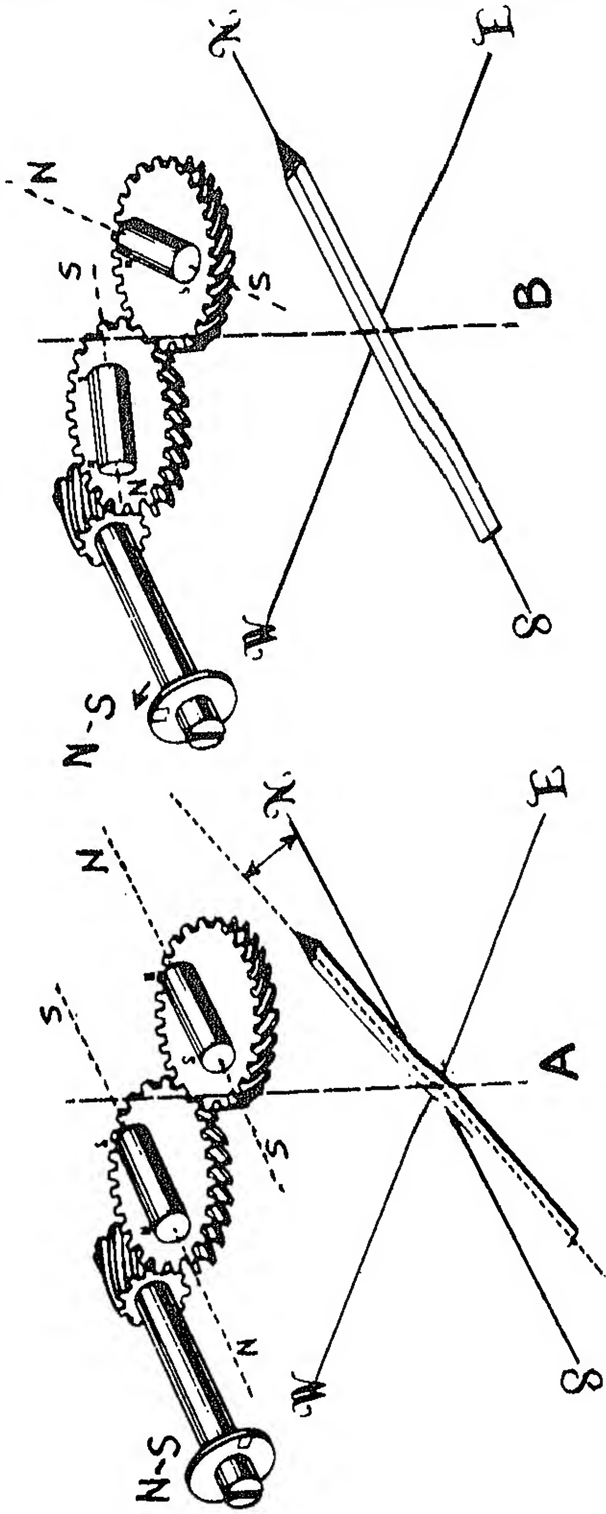
c. Correction

(1) Process

(2) Method

SG 3.2.7


DIRECT READING MAGNETIC COMPASS
1
2
8
7
5
3
6
9
4
13
10
11
12
1. FLOAT
2. PIVOT
3. DIRECTIVE MAGNET
4. CARD
5. CASE
6 JEWEL POST
7. JEWEL
8. FILLER CAP
9. EXPANSION UNIT
10. LENSE
11. LUBBER LINE
12. COMPENSATOR
13. COMPENSATING MAGNET
A(5-1-2)



COMPENSATING DEVICE

1. Complete the statement explaining the purpose of the direct reading magnetic compass.

2. Match each component of the direct reading magnetic compass listed in Column A to its function listed in Column B.

Column A COMPONENTS	Column B FUNCTIONS
___(1) Directive Magnets	a. Compensates for changes of the volume of the compass fluid due to altitude and temperature changes.
___(2) Expansion Unit	b. Align themselves with the magnetic field present.
___(3) Compensating Magnets	c. Reduce the effects of the undesired magnetic fields.
	d. Reduces friction between the jewel post and float pivot.

3. Select the statements which describe the compensating device.

   a. Two permanent bar magnets with like poles in the same direction.

   b. Two permanent bar magnets parallel to each other with unlike poles in the same direction.

   c. The flux lines produced affect the position of the directive magnets.

   d. Reduces the effects of undesired magnetic fields.

   e. Compensates for volume changes of the compass fluid due to altitude or temperature changes.

CT 3.2.7

4. Match each type of compass error listed in Column A to its cause listed in Column B.

Column A Compass Errors	Column B Causes
a. Variation	___(1) Large deposits of high permeable material.
b. Deviation	___(2) Electromagnetic fields
	___(3) Misalignment of the compass with the longitudinal axis of the aircraft.
	___(4) Varying atmospheric conditions

5. Match each type of compass error listed in Column A to the method used for correction listed in Column B.

Column A Compass Errors	Column B Method of Correction
___(1) Deviation	a. Swinging the compass
___(2) Variation	b. Aeronautical charts

CT 3.2.7

1. Where are the directive bar magnets located?

   Answer ____________________.

2. How do we dampen the swing and oscillation of the float assembly?

   Answer ____________________.

3. How are the cardinal headings marked on a compass card?

   Answer: ____________________.

4. What unit compensates for altitude and temperature changes?

   Answer: ____________________.

5. The fixed reference used to read the compass card is called:

   Answer: ____________________.

6. What type of compensating device is used?

   Answer: ____________________.

7. Maximum effect is obtained when the reference dots are how far apart?

   Answer: ____________________.

8. The difference between the direction indicated by an undisturbed magnetic compass and true direction is called what?

   Answer: ____________________.

9. Large deposits of highly permeable material in the earth will cause what kind of compass error?

   Answer: ____________________.

10. What is the term used for the difference between the heading of the aircraft, as indicated by a magnetic compass, and the actual heading of the aircraft?

Answer: ______________________.

11. What kind of error would an electric motor cause to a direct reading compass?

Answer: ______________________.

WS 3.2.7

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. MATCH statements to the type of direct reading magnetic compass check indicated.
2. SELECT the statements which pertain to the aircraft electrical equipment prior to swinging the compass.
3. LABEL the compass rose with the correct magnetic meridians in degrees.
4. MATCH the formulas with the coefficients to which they apply.
5. COMPUTE the deviation errors and/or magnetic compass readings in accordance with given known values.
6. WRITE the steps of swinging and compensating the direct reading magnetic compass in the proper sequence.
7. PERFORM the compass swing on a training device.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 523-526

OUTLINE:

1. Maintenance
   a. Visual inspection
      (1) Fluid
         (a) Amount

         (b) Condition

      (2) Float assembly

   b. Operational check

2. Compensation
   a. Compass rose

   b. Preparation of the plane for the compass rose.

   c. Precautions at the compass rose.

d. Use of the compass rose.

CRITERION SELF-TEST

1. Match the statements listed in Column A to the type of check indicated in Column B.

Column A		Column B
a. Float unbalance caused by one of the directive magnets being vibrated loose.	____	(1) Visual
b. Rotating compass 360° to check for smoothness of operation.	____	(2) Operational
c. Check fluid level.		
d. Check if fluid is dark, caused by old age.		
e. Deflect compass card 30° with a magnetic material, and check for overshoot when the material is removed.		

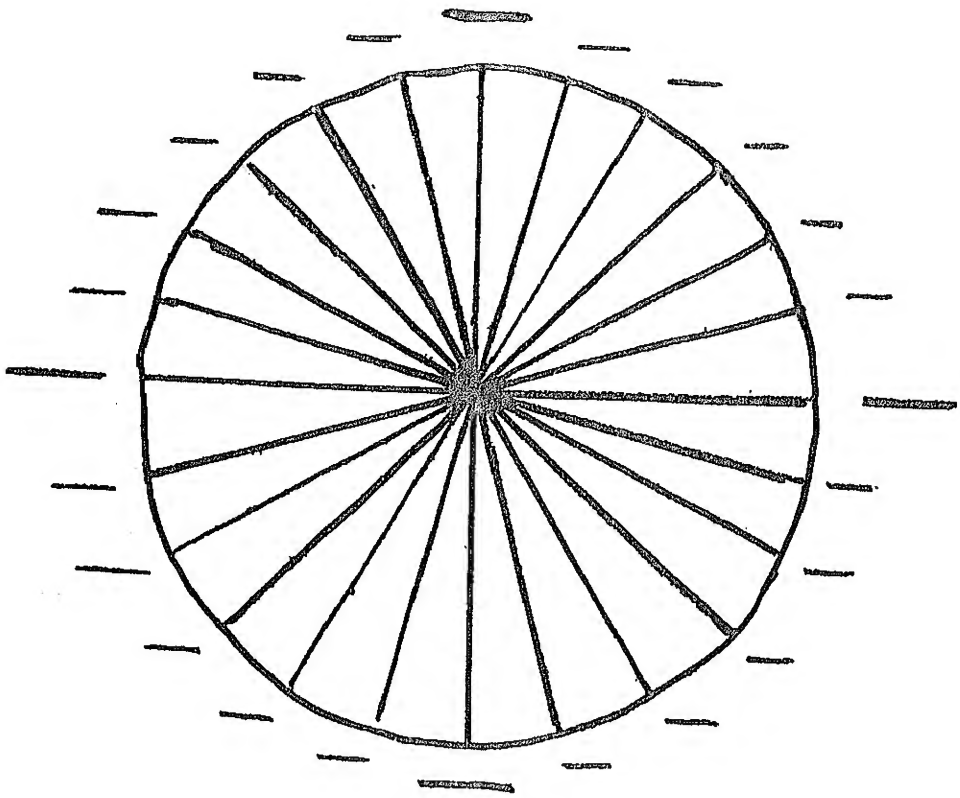
2. Select the statement(s) which pertain(s) to the aircraft's electrical equipment prior to swinging the compass.

   a. Only essential flight equipment should be operating.

   b. All electrical equipment should be off.

   c. All electrical equipment should be the same as in normal flight.

3. Label the compass rose with the correct magnetic meridian's in degrees.



4. Match the formulas with the coefficients to which they apply.

_____(1) Coefficient B.

_____(2) Coefficient C.

_____(3) Coefficient A

a. $\frac{\text{Deviation N}-\text{Deviation S}}{2}$

b. $\frac{\text{Dev N}+\text{Dev S}+\text{Dev E}+\text{Dev W}}{4}$

c. $\frac{\text{Deviation E}-\text{Deviation W}}{2}$

Compute the deviation errors and/or magnetic compass readings in accordance with given known values.

Actual Aircraft Heading	Magnetic Compass Reading	Deviation Error
N (000°)	004°	______
N (000°)	357°	______
E (090°)	85°	______
E (090°)	92°	______
S (180°)	______	+2°
S (180°)	176°	______
W (270°)	______	+3°
W (270°)	272°	______

. Identify the steps of swinging and compensating the direct reading magnetic compass listed in Column A in their proper sequence in Column B.

Column A	Column B STEP
a. Apply coefficient "A" by realigning the compass.	____(1)
b. Place aircraft on rose heading south (180°) and record deviation error.	____(2)
c. Rotate aircraft to east (090°) and record deviation error.	____(3)
d. Rotate aircraft to north (000°) and record deviation error.	____(4)
e. Apply coefficient "C" by adjusting N-S compensating screw.	____(5)
f. Rotate aircraft to west (270°) and record deviation error.	____(6)
g. Apply coefficient "B" by adjusting E-W compensating screw.	____(7)
h. Complete correction card.	____(8)

CT 3.2.3

TIME: Hours 1 Minutes 40 Periods 2

EQUIPMENT LIST:

1. Mock-up of Aircraft Compass Rose
2. Direct-Reading Magnetic Compass
3. Nonmagnetic Screwdriver

PROCEDURE:

STEP 1: Null compass

a. Match dot on N-S compensating screw with the dot on the case.
b. Match dot on E-W compensating screw with the dot on the case.

NOTE: Place your mock-up of the compass rose so that the 000° setting is pointing in the general northerly direction for this area. From this point on, use caution so that you do not move your mock-up.

STEP 2: Rotate aircraft to the south.

NOTE: When moving the aircraft, do so in a clockwise direction.

a. Align the longitudinal axis with the 180° reference line.
b. When the compass settles, record the actual heading in the space provided on the work sheet.
c. Determine and record the amount of deviation in the next column as provided on the work sheet.

NOTE: If you read above 180°, you must subtract that amount to read 180°; the amount of deviation is therefore assigned a minus sign number. If below 180°, it is assigned a positive sign number.

STEP 3: Rotate the aircraft to west heading.

a. Align longitudinal axis with 270° reference line.
b. When the compass settles, record actual heading in the space provided on work sheet.
c. Determine and record the amount of deviation in the space provided on the work sheet.

STEP 4: Rotate aircraft to north heading.

a. Align longitudinal axis with 000° reference line.
b. When the compass settles, record the actual heading in the space provided on the work sheet.
c. Determine and record the amount of deviation.
d. Solve for coefficient "C" in the space provided on work sheet, showing math computation in three steps.
e. Have instructor initial ________.
f. Record coefficient "C" in space provided on work sheet.
g. Apply coefficient "C" to compass heading (N) by turning N-S compensating screw.
   (1) If positive, add the required number of degrees to the north heading.
   (2) If negative, subtract the required number of degrees from the north heading.
h. Mathematically apply coefficient "C" to the opposite heading (south) on the work sheet.
   (1) If coefficient "C" was added to the north heading, it will be subtracted from the south
   (2) If coefficient "C" was subtracted from the north heading, then add it to the south.

STEP 5: Rotate aircraft to east.

a. Align longitudinal axis with 090° reference line.
b. When compass settles, record actual heading on work sheet.
c. Determine and record amount of deviation.
d. Solve for coefficient "B" on work sheet.
e. Have instructor initial _____.
f. Record coefficient "B" on work sheet.
g. Apply coefficient "B" to compass heading (east) by turning the E-W compensating screw.
   (1) If coefficient "B" is positive, add required number of degrees to east heading.
   (2) If coefficient "B" is negative, subtract the required number of degrees from east heading.

h. Mathematically apply coefficient "B" to the opposite heading (west) on work sheet.
   (1) If coefficient "B" was added to the east heading, it will be mathematically subtracted from the west heading.
   (2) If coefficient "B" was subtracted from the east heading, it will be mathematically added to the west heading.

i. Solve for coefficient "A" on work sheet, showing mathematical procedure.

NOTE: Use original amounts of deviation.

j. Have instructor initial ________.

k. Record coefficient "A" on the work sheet in the space provided and mathematically apply to all headings.

l. Apply coefficient "A" to the compass as follows:
   (1) Keeping the nose of the aircraft on 090° rotate the compass clockwise if coefficient "A" is positive.
   (2) If coefficient "A" is negative, keep the nose of aircraft on 090° and move the compass in a counterclockwise direction.

   NOTE: Applying coefficient "A" removes the alignment error caused by installation.

STEP 6: Prepare correction card

a. With the aircraft on east, fill in the correction card with the four cardinal headings on the work sheet.

b. Swing aircraft to 120° heading.
   (1) Allow the compass to settle.
   (2) Record compass heading in space provided on the work sheet.

c. Repeat above operation every 30° until the correction card is completely filled in.

STEP 7: Upon completion of this assignment, report to your instructor so that he may verify the correctness of your work.

Instructor's Initial __________

MAGNETIC COMPASS COMPENSATION

Mag. Heading	Comp. Reads.	Mag. Dev.	Co-eff. "C-B"	Comp. Reading	Co-eff "A"	Compensated Headings
180			X X X		X X X	
270			X X X		X X X	
000			C =		X X X	
090			B =		A =	

COMPASS CORRECTION CARD

Magnetic Heading	000	030	060	090	120	150	180	210	240	270	300	330
Compass Heading												

SHOW COMPLETED MATH WORK BELOW IN THREE STEPS.

Co-eff. "C" = $\frac{(N)-(S)}{2}$

Co-eff. "B" = $\frac{(E)-(W)}{2}$

Co-eff. "A" = $\frac{(N)+(E)+(S)+(W)}{4}$

JS 3.2.8

Work Sheet   Maintenancé and Compensation of the Direct Reading Magnetic Compass

---

1. The compensating device must be (a) before compensating the compass.   (a) ________

2. Normal (b) conditions should be approximated in the aircraft when compensating the compass.   (b) ________

WS 3.2.8

Major Enabling Objective: Upon completion of this lesson, the student will be able to identify computers by matching the class of computer to its characteristics. The standard is 100 percent accuracy.

Minor Enabling Objective: Upon completion of this lesson, the student will be able to identify the types of computers by selecting the correct statement(s) from a list of four. The standard is 100 percent accuracy.

Lesson Topic Learning Objectives: Upon completion of this lesson topic the student will be able to, with 100 percent accuracy:

1. SELECT from a list the definition of a computer.

2. SELECT from a list the principle advantages of all computers.

3. MATCH the two types of computers with the statement(s) that pertains to each.

4. SELECT from a list of four the statement(s) that describe(s) the classes of computers.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 355-356

OUTLINE:

1. Definition

   a.

   b.

2. Types

a. Analog

b. Digital

SG 3.2.14

3. Characteristics:

4. Classes

   a. Special Purpose

   b. General Purpose

1. SELECT the definition of a computer.

   a. A machine that utilizes human intervention to carry out specific mathematical solutions.

   b. A machine for carrying out calculations and specified transformations on information.

   c. An electronic brain that solves problems of all types.

   d. A machine with the ability to think out solutions to all problems.

2. SELECT the principal advantage(s) of all computers.

   a. The ability to store knowledge.

   b. The ability to reason.

   c. The ability to solve complex problems with great speed.

   d. Flexibility

3. MATCH the two types of computers with the statements to which they pertain.

Types		Statements
a. Analog	_____(1)	A computer that solves problems by processing data that is of a fixed and distinct value.
b. Digital	_____(2)	A computer that solves problems by processing data with continually varying values to provide continually varying solutions.
	_____(3)	A computer that uses amplifiers, servo-mechanisms, gears, cams, etc., in solving problems.
	_____(4)	A computer that uses gating and switching circuits in solving problems.

4. SELECT the statement(s) that describe the classes of computers.

   a. A computer with basic elements combined for specialized applications.

   b. A hybrid computer used for special applications.

   c. A non-hybrid computer used for general applications.

   d. A computer which contains more basic elements than may be required for accomplishing any one particular job.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the purpose of the Air Data Computer System.

2. LABEL the sensors that provide information to the Air Data Computer.

3. SELECT from a list the function of the Air Data Computer.

4. MATCH each Air Data computer corrected output to its application.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 313-315

OUTLINE:

1. Purpose
   a.

   b.

2. Sensors
   a. Static vent

   b. Pitot tube

   c. Temperature bulb

    d. Angle of attack probe

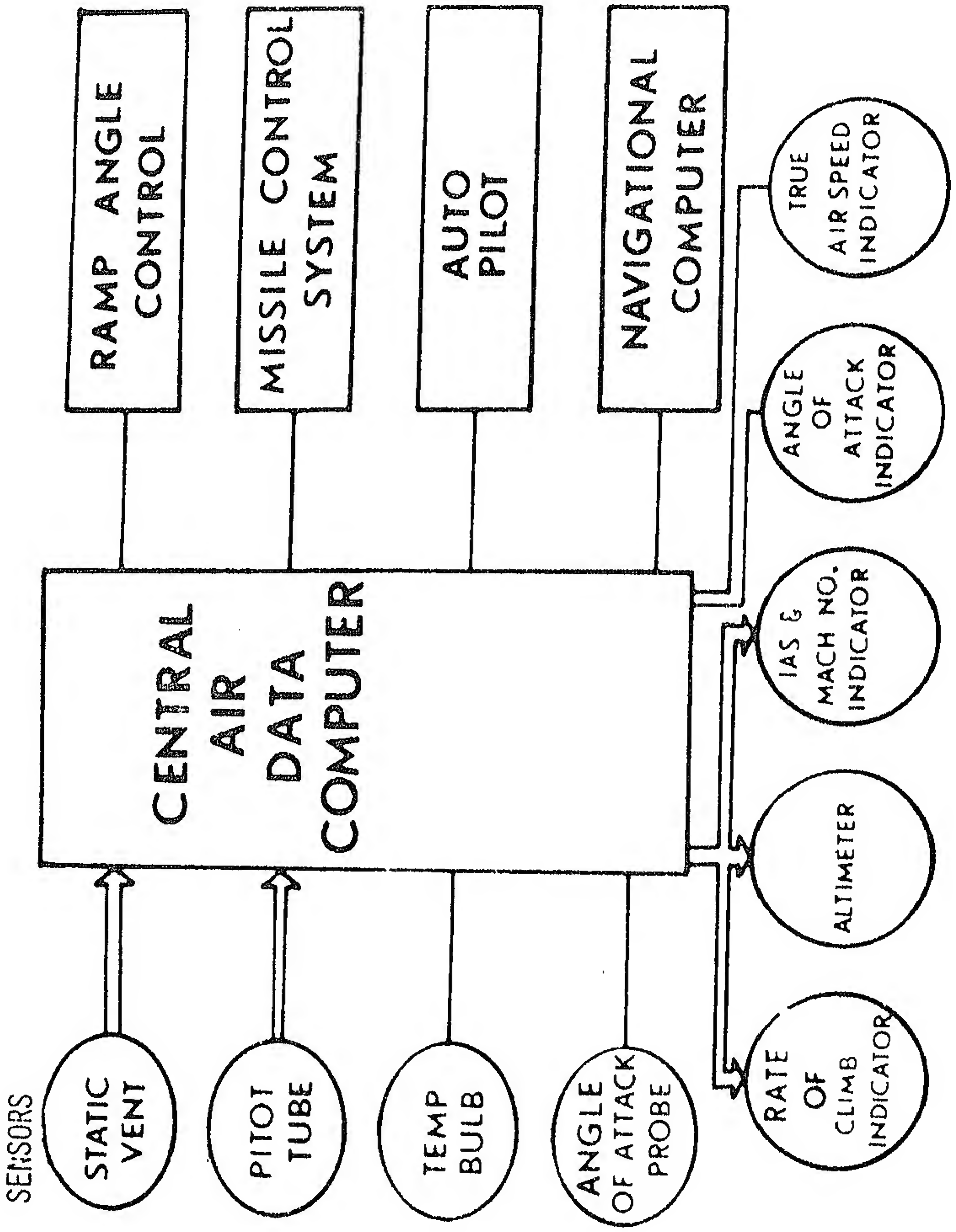
3. Central air data computer
    a. Function

    b. Components

4. Corrected outputs
    a. True static pressure

    b. True air speed

    c. Ramp angle signal

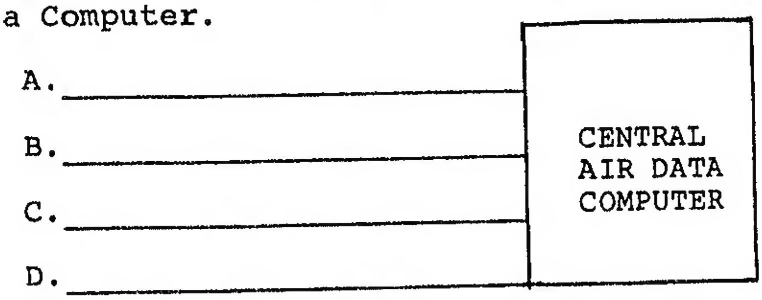


BLOCK DIAGRAM TYPICAL AIR DATA COMPUTER SYSTEM

1. Select the purpose of the Air Data Computer.

   a. Provides information to Navigational computer, autopilot, missle control system, ramp control, and cockpit instruments.
   b. Takes uncorrected static, pitot pressure, and outside temperature and converts them to true pressure and temperature.
   c. Takes corrected pressures and temperatures and applies them to navigation computer, autopilot, missle control system, ramp control, and cockpit instruments.

2. Label the sensors that provide information to the Air Data Computer.



3. Select the function of the Air Data Computer

   a. Electrical and pneumatic data from the sensing components are combined to provide corrected static and pitot pressure.
   b. Electrical data from the sensing components are combined to provide corrected static and pitot pressure.
   c. Pneumatic data from the sensing components are combined to provide corrected static and pitot pressure.

4. Match each output listed in Column A to its application listed in Column B.

Column A OUTPUT	Column B APPLICATION
a. True static pressure	___(1) Rate of climb indicator
b. True airspeed	___(2) Navigational computer
c. Ramp angle signal	___(3) Air inlet to engine
	___(4) True airspeed indicator
	___(5) Missile control system
	___(6) Mach indicator
	___(7) Auto pilot
	___(8) Altimeter

Work Sheet | Air Data Computer

1. ____________________ and ____________________ data from the sensing components are combined to provide corrected static and pitot pressure.

2. True airspeed is indicated airspeed that has been corrected for ____________________ and ____________________.

3. The ____________________ is located at the air inlet of the jet engine.

4. Air data computer receives atmospheric pressure from ____.

5. Temperature bulb measures ________________ ____________.

WS 3.2.9

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the definition of a gyroscope.
2. MATCH the rotor and inner and outer gimbals to their function and/or description.
3. MATCH the two types of gyros with their functions.
4. SELECT from a list the definition of rigidity.
5. SELECT from a list the factor affecting the amount of rigidity of the spinning mass.
6. SELECT from a list the definition of precession.
7. MATCH each type of gyro drift with a statement to which it pertains.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 317-321

OUTLINE:

1. The gyroscope
   a. Definition
      (1) Gyroscope

      (2) Spin

      (3) Turn

      (4) Tilt

b. Nomenclature
(1) Rotor

(2) Gimbal rings

(3) Case

c. Types
(1) Free gyro

(2) Restricted gyro

2. Rigidity
a. Definition

b. Explanation

c. Amount of rigidity
(1) Speed of rotating mass

(2) Weight of mass

(3) Diameter of mass

3. Precession
   a. Definition

   b. Explanation

   c. Rate

   d. Drift

      (1) Mechanical
         (a)

         (b)

      (2) Apparent rotation (precession)
         (a)

         (b)

         (c)

1. Select the definition of a gyroscope.

   a. A spinning mass having one freedom of movement.

   b. A spinning mass having two freedoms of movement.

   c. A spinning mass having three freedoms of movement.

2. Match the rotor and inner and outer gimbals listed in Column A to their functions and/or description listed in Column B.

Column A		Column B
a. Rotor	___(1)	Metal ring used to support spinning mass
b. Inner gimbal	___(2)	Gives inner gimbal its freedom to tilt
c. Outer gimbal	___(3)	Can be various shapes, designs, and weight
	___(4)	Gives rotor freedom to spin
	___(5)	Non-magnetic material
	___(6)	Supports the inner gimbal

3. Match the two types of gyros listed in Column A with their functions listed in Column B.

Column A TYPE		Column B FUNCTION
a. Free gyro	___(1)	Semi-rigidly mounted
b. Restricted gyro	___(2)	Universally mounted
	___(3)	Used as rate of turn indicator
	___(4)	Used as navigation and attitude instruments

CT 3.2.10

4. Select the definition of rigidity.

   a. The property of a spinning mass that makes it attempt to hold a fixed position in space.

   b. The resultant movement of a spinning mass when a force is applied, trying to change the spin axis.

5. Select the factors affecting the amount of rigidity of the spinning mass.

   a. Amount of force applied

   b. Speed of the mass

   c. Weight of the mass

   d. Diameter of the mass

6. Select the definition of precession.

   a. The property of a spinning mass that makes it attempt to hold a fixed position in space.

   b. The resultant movement of a spinning mass trying to change its spin axis when a force is applied.

7. Match the type of gyro drift listed in Column A to a statement to which it pertains listed in Column B.

Column A	Column B
a. Mechanical	____(1) Bearing friction will cause a force to be applied to gyro and it will precess.
b. Apparent rotation	____(2) Caused from gyro remaining fixed in space and the earth rotating once every 24 hours.
	____(3) Rotor unbalance

1. A gyroscope is a ________ __________ universally mounted so that it has ___________ freedoms of movement.

2. The rotor is made of a ________ - __________ material.

3. The inner gimbal ring can also be called the rotor ______________.

4. Some of the factors that affect rigidity are ____________, ______________, and _____________ of the mass.

5. Bearing friction can cause ________________ precession of the gyroscope.

6. _____________ _______________ is caused by the earth's rotation.

WS 3.2.10

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the function of the turn and bank indicator.

2. MATCH each ball position to the condition of the aircraft.

3. MATCH each component of the turn indicator to its function and/or construction.

4. SELECT from a list the gyroscopic principle of operation of the turn and bank indicator.

5. SELECT from a list the method used that allows the indicator pointer to indicate in the direction of the turn.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Pages 322-326

OUTLINE:

1. Function
   a.

   b.

2. Bank Indicator
   a. Construction
      (1)

      (2)

      (3)

b. Operation
(1)

(2)

(3)

(4)

3. Turn Indicator
a. Construction
(1) Motor Assembly

(a)

(b)

(c)

(d)

1.

2.

(2) Damping unit

(a)

(b)

(c)

(3) Indicating assembly

(4) Adjuster retaining spring

(a)

(b)

(c)

b. Operation

(1)

(2)

(3)

(4)

(5)

(6)

(7)

1. Select the function(s) of the turn and bank indicator.

   a. Indicates rate of turn in degrees per minute about the longitudinal axis and provides a reference for proper execution of a coordinated turn.

   b. Indicates rate of turn in degrees per minute about the lateral axis and provides a reference for proper execution of a coordinated turn.

   c. Indicates rate-of-turn in degrees per minute about the vertical axis and provides a reference for proper execution of a coordinated turn.

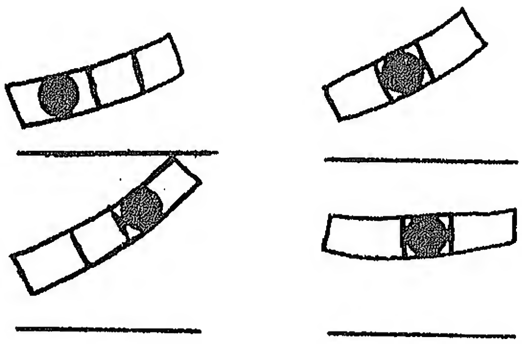
2. Match the ball position to the condition of the aircraft.

   a. Straight and level

   b. Coordinated turn

   c. Skid

   d. Slip



3. Match each component of the turn indicator listed in Column A to its function and/or construction listed in Column B.

Column A
COMPONENT

a. Motor assembly

b. Damping unit

c. Indicating assembly

d. Adjuster retainer spring

Column B
FUNCTION

____(1) Absorbs vibrations and oscillations

____(2) Mounted in gimbal ring, and called a gyrostat

____(3) Controls rate of precession

____(4) Consists of dial and pointer

____(5) Controls amount of precession

____(6) Returns pointer to neutral after completion of turn

4. Select the gyroscopic principle of operation of the turn and bank indicator.

   a. Rigidity

   b. Precession

   c. Drift

5. Select the method used that allows the indicator pointer · - indicate in the direction of the turn.

   Precession in same direction.

   Mechanical linkage.

CT 3.2.11

1. The turn and bank indicator indicates the rate of turn in ________ ________ ____________ about the ________ axis of the aircraft.

2. The bank indicator operates on ______________ and ___________ force.

3. The motor assembly and gimbal is called a ______________.

4. The adjuster retaining spring controls ______________ __________ __________ and returns the gyrostat to __________ after a turn.

5. The turn indicator operates on the principle of ________ ____________________.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the definition of a synchro.

2. SELECT from a list the type of synchro utilized for voltage amplification.

3. SELECT from a list the type of synchro which uses more than one item of information.

4. SELECT from a list the statement which describes stator construction of a simple synchro transmitter.

5. SELECT from a list the method of connecting excitation voltage to the rotor of a simple synchro transmitter.

6. MATCH two conditions of current flow in stator leads to position of transmitter and receiver rotors.

7. COMPLETE a schematic diagram of a simple synchro system by properly connecting the rotor and stator leads.

8. SELECT from a list the component that compensates for oscillation of the receiver rotor of a simple synchro.

9. SELECT from a list the statement describing connection of rotor leads in a simple synchro system.

10. SELECT from a list the statement describing the method of reversing rotation of a simple synchro receiver.

11. SELECT from a list the definition of a differential synchro system.

12. SELECT from a list the statement describing rotor construction of a differential synchro transmitter.

13. SELECT from a list the definition of a control synchro system.

14. LIST the factors affecting accuracy of a synchro system.

REFERENCE:

Basic Electricity, NAVPERS 10086-B, Pages 415-427

OUTLINE:

1. Description
    a. Definition

    b. Types
        (1)

        (2)

        (3)

2. Common trade names

3. Advantages
   a.

   b.

   c.

   d.

4. Types
   a. Simple synchro system
      (1) Construction
         (a) Transmitter - TX
            1.

            2.

(b) Receiver - TR

1.

2.

(c) Lead markings

1.

2.

3.

4.

(2) Operation

(a)

(b)

(c)

(d)

(e)

(f)

(g)

b. Differential synchro system
   (1)

   (2)

   (3)

   (4)

c. Control synchro system
   (1)

   (2)

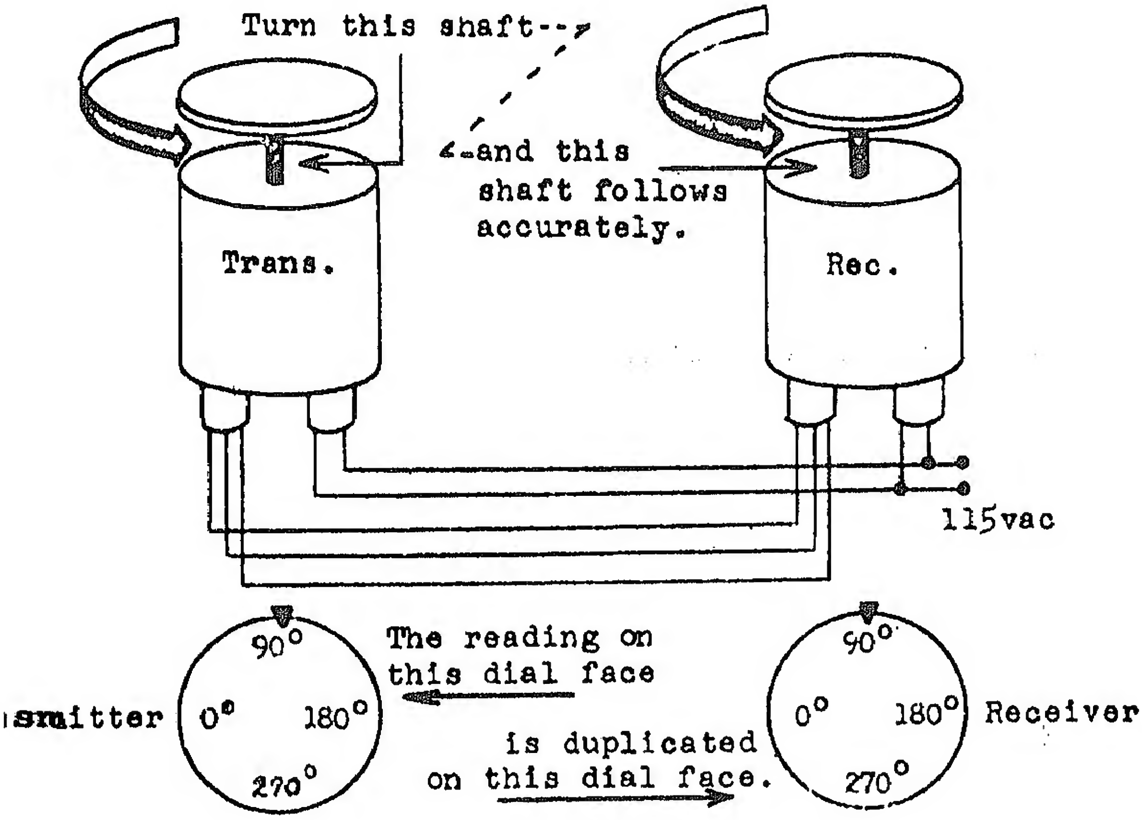
   (3)

5. Factors affecting accuracy
   a.

   b.

   c.

SYNCHRO TRANSMITTERS AND RECEIVERS



le Synchro System

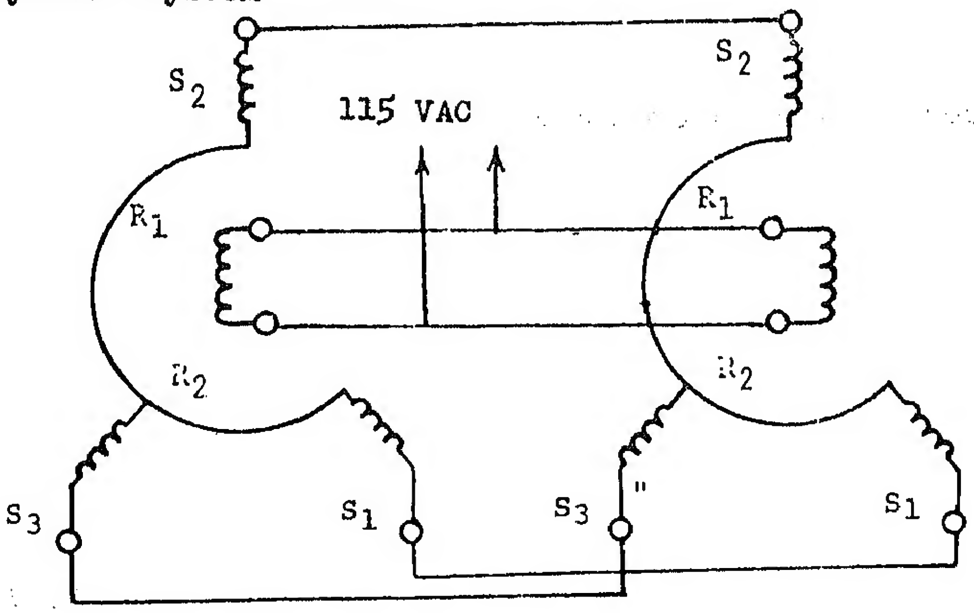
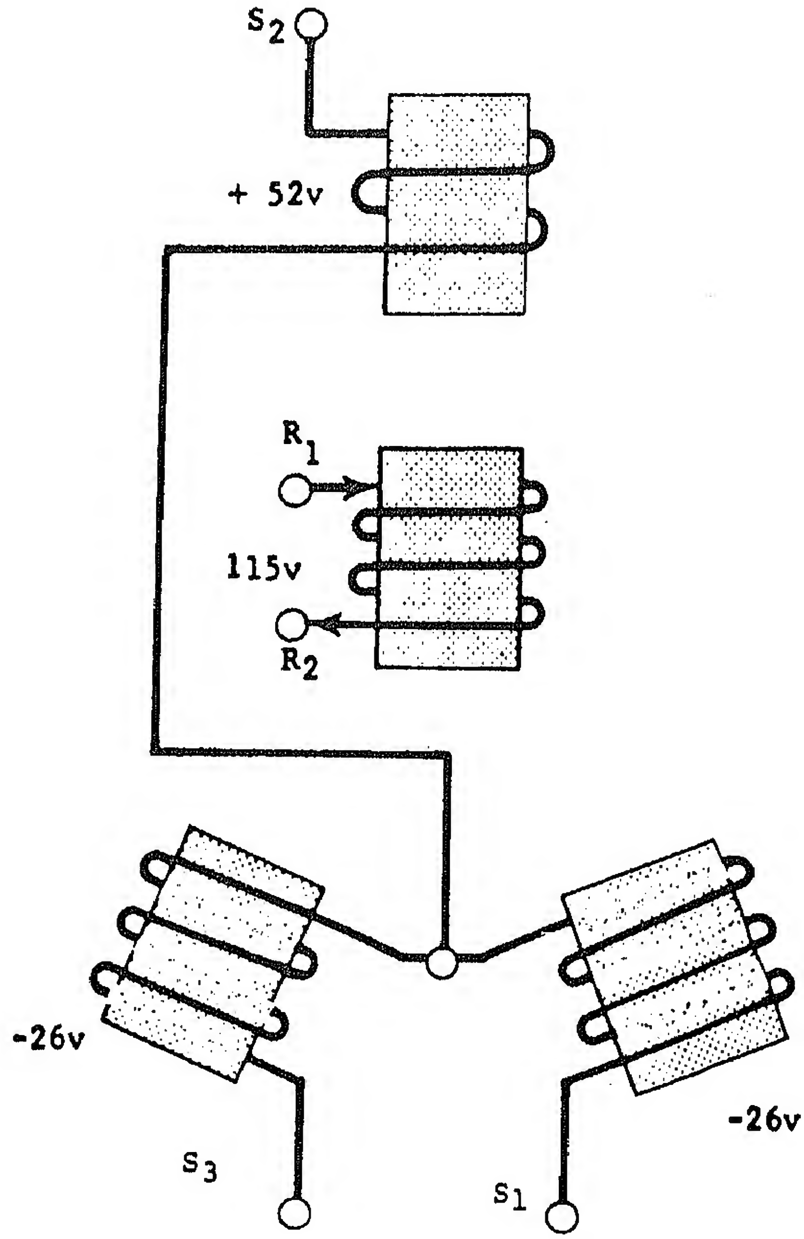


DIAGRAM OF SIMPLE SYNCHRO TO ILLUSTRATE OPERATION



METHOD OF FINDING ELECTRICAL ZERO

DIFFERENTIAL SYNCHRO SYSTEM

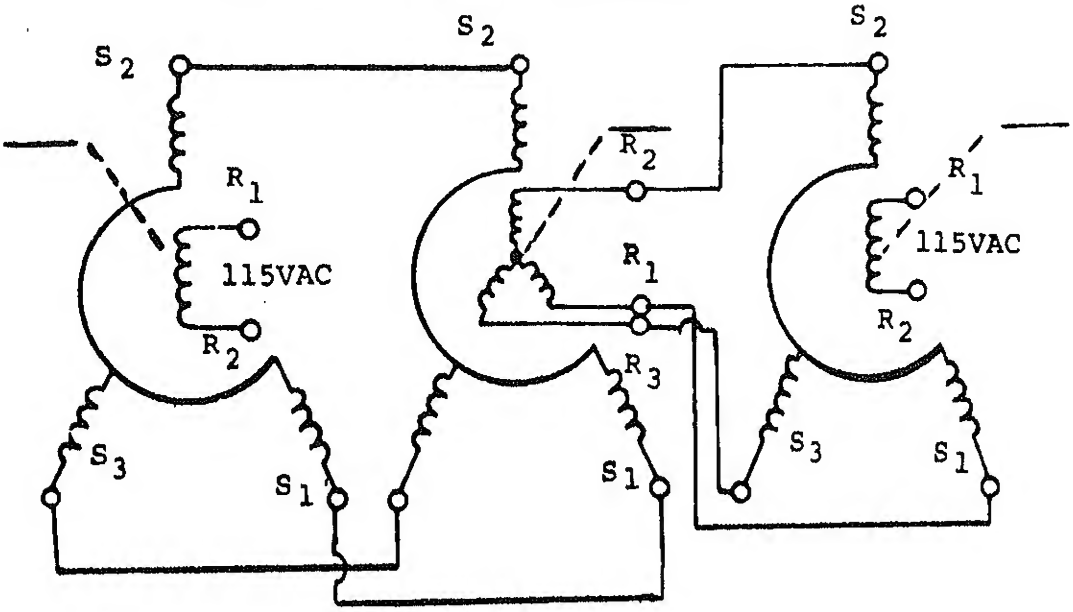
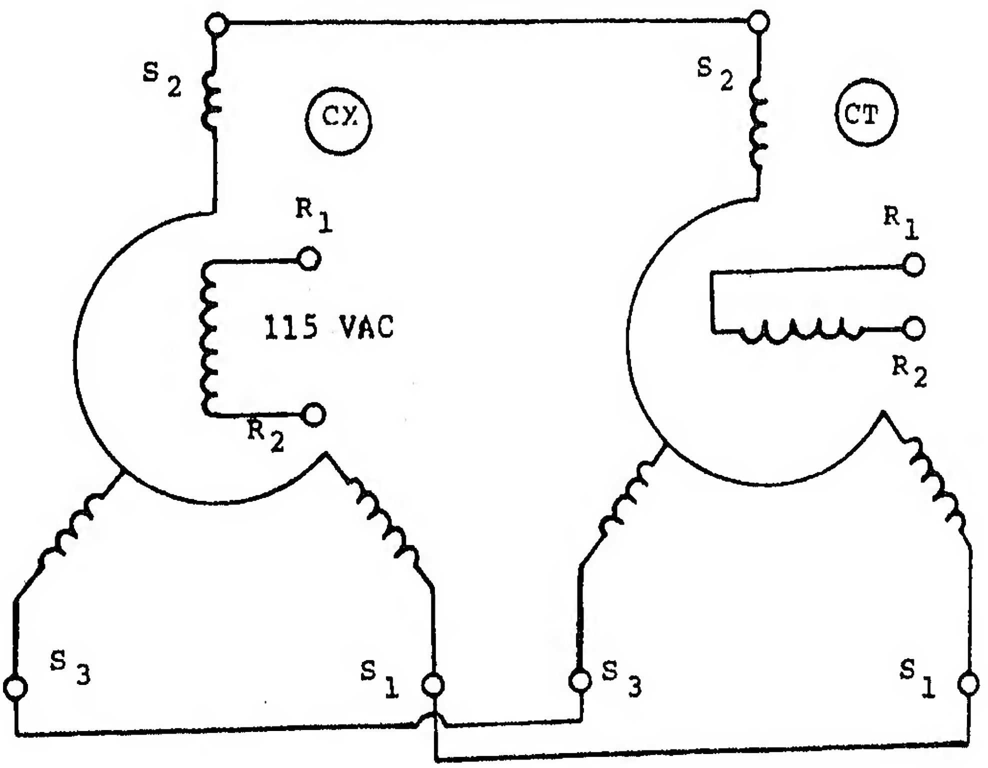


DIAGRAM OF A CONTROL SYNCHRO SYSTEM



1. Select the definition of a synchro.

   a. A mechanical device that converts electrical movement to an electrical signal.

   b. An electrical device that converts mechanical movement to an electrical signal.

2. Select the type of synchro utilized for voltage amplification.

   a. Simple
   b. Differential
   c. Control Transformer

3. Select the type of synchro which uses more than one item of information.

   a. Simple
   b. Differential
   c. Control Transformer

4. Select the statement that describes stator construction of a simple synchro transmitter.

   a. Wye connected - 120° apart.
   b. Parallel with rotor coil
   c. In parallel - 120° apart

5. Select the method of connecting excitation voltage to the rotor of a simple synchro transmitter.

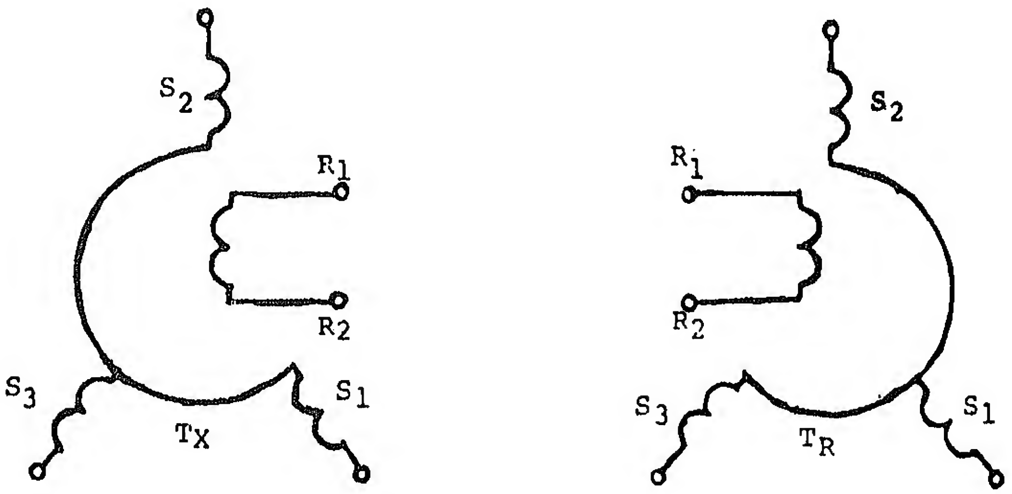
   a. Inertia damper
   b. Sliprings
   c. Hairsprings

6. Match the two conditions of current flow in the stator leads listed in Column A to the position of transmitter and receiver rotors listed in Column B.

Column A	Column B
____(1) Rotors in correspondence	a. No current flow in stators
____(2) Rotors in synchronous position	b. Current will flow in stators
____(3) Rotors not in correspondence	

CT 3.1.1

7. Complete the schematic below by properly connecting the stator and rotor leads.



8. Select the component which compensates for oscillation of the rotor in the receiver of a simple synchro.

   a. Magnetic torquer
   b. Sliprings
   c. Inertia damper
   d. Drag disc assembly

9. Select the statement describing connection of rotor leads in a simple synchro system.

   a. In series with power source
   b. In parallel with stator leads
   c. In parallel with power source

10. Select the statement describing the method of reversing rotation of a simple synchro receiver.

    a. Reverse leads S_1 and S_3

    b. Reverse leads R_1 and R_2

    c. Reverse leads R_1 and R_3

CT 3.1.1

11. Select the definition of a differential synchro system:

    a. A system providing an output to drive a servo-mechanism.

    b. A system used to interpret the sum of two angular motions and indicate their resultant.

12. Select the statement describing the rotor construction of a differential synchro transmitter.

    a. Two coils in series
    b. One coil only
    c. 3 coils 120° apart

13. Select the definition of a control synchro system.

    a. A system used to interpret the sum of two angular motions.

    b. A system providing an output voltage which commands movement of a servo-mechanism.

14. List the factors affecting accuracy of a control synchro system.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

CT 3.1.1

1. A simple synchro system transmits_____item(s) of information from one point in an aircraft to another____________ ____.

2. List four advantages of synchros.

   a. ____

   b. ____

   c. ____

   d. ____

3. The stator coils of a simple synchro are divided into ______________ groups connected _________electrical degrees apart.

4. Why must a synchro unit be electrically zeroed? _________ ____.

5. When the rotors of the transmitter and receiver are in correspondence, there is ____________ current between stators.

6. A synchro converts __________ ___________ or ________________ to an ______________ __________________.

7. The three synchro types are _______________, ________________ and ________________ ____________________.

WS 3.1.1

8. Why would we want S_1 of the transmitter connected to S_3 of the receiver and S_3 of the transmitter connected to S_1 of the receiver? ____________________

9. The differential synchro system will interpret the ______ or ______________ of two angular motions and transmit the resultant.

10. The output of a control synchro system is used to control the movement of a ______________ ____________________.

Lesson Topic Learning Objectives: Upon completion of this lesson the student will be able to, with 100 percent accuracy:

1. SELECT from a list the purpose of the Synchro/Autosyn Indicating System.

2. SELECT from a list five types of aircraft systems that utilize the Synchro/Autosyn Indicating System.

3. MATCH the transmitter rotors' mechanical actuating linkages to their related indicating systems.

4. SELECT from a list the statement which states the difference amont autosyn indicators.

5. MATCH two malfunctions of an Autosyn Indicating System with possible causes.

6. PERFORM operational check and troubleshooting of an Autosyn Indicating System on a training device.

REFERENCE:

Aviation Electrician's Mate 3 & 2, NAVEDTRA 10348-D, Chapter 15

OUTLINE:

1. Purpose

2. Application
   a.

b.

c.

3. Construction
   a.

   b.

4. Operation
   a.

b.

5. Maintenance and Testing

a.

b.

c.

SG 3.1.2

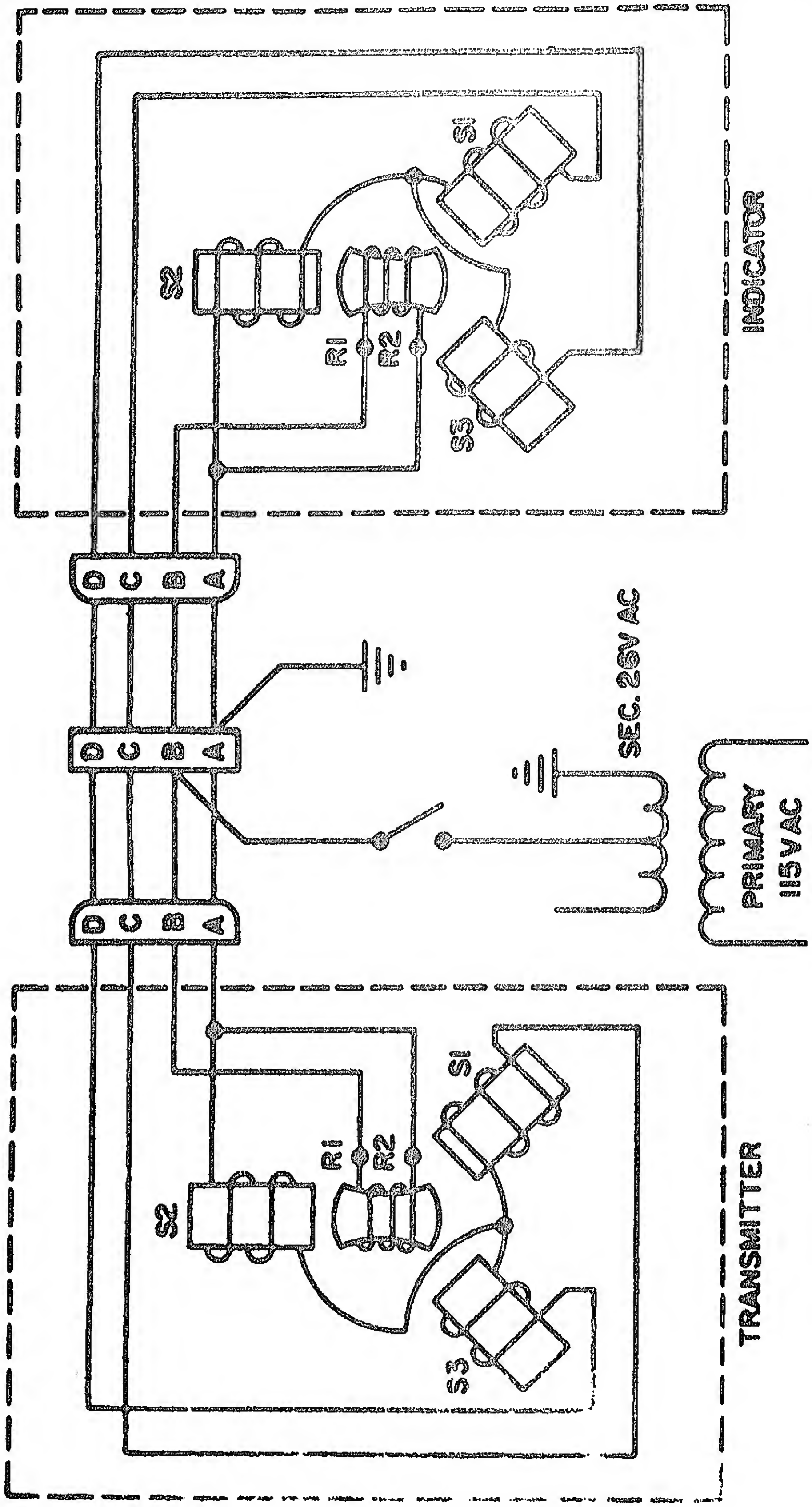

INDICATOR
S1
S2
S3
R1
R2
D
C
B
A
SEC. 26V AC
PRIMARY
115VAC
400 hertz
TRANSMITTER

FIGURE 1

1. Select the purpose of synchro/autosyn indicating systems.

   a. Provides a method for converting a pressure to a mechanical function.

   b. Provides a mechanical means for transmitting electrical functions to the pilot's instrument panel.

   c. Provides a means for transmitting an electrical signal to remote points in the aircraft.

   d. Provides an electrical means for transmitting mechanical functions to remote points in the aircraft.

2. Select five types of aircraft systems that utilize the Synchro/Autosyn Indicating System.

a. T.A.S. Indicator	e. Altimeter
b. Fuel flow	f. Fuel quantity
c. Oil pressure	g. Manifold pressure
d. Fuel pressure	h. Hydraulic pressure

3. Match each transmitter rotors' mechanical actuating linkages listed in Column A to its related indicating system listed in Column B.

Column A	Column B
___(1) Manifold pressure	a. Diaphragm
___(2) Fuel pressure	b. Spring loaded vane
___(3) Oil pressure	c. Bourdon tube
___(4) Fuel flow	d. Bellows assembly
___(5) Hydraulic pressure	

4. Select the statement which states the difference among autosyn indicators.

   a. The stator and rotor construction

   b. The dial scale

   c. Excitation voltage to the rotor

   d. Means of rotor movement

5. Match each malfunction of an autosyn indicating system listed in Column A to its possible cause listed in Column B. Refer to schematic diagram.

Column A POSSIBLE CAUSE	Column B MALFUNCTION
___(1) Pin "B" of indicator plug open	a. No operation
___(2) Pin "B" of transmitter plug open	b. Erratic operation
___(3) Terminal "A" open to ground	
___(4) Pin "A" of transmitter plug open	
___(5) Pin "C" of indicator plug open	
___(6) Terminals "C" and "D" open	

WORK SHEET SYNCHRO/AUTOSYN INDICATING SYSTEMS

1. The purpose of the synchro/autosyn indicating system is to provide an ________________ means of transmitting ________________________________ to remote points in the aircraft.

2. The advantages of this system are that it saves ________ and ________________________, and aids in eliminating ____.

3. The power requirements of the system are ______________ ____________________________________ single phase.

4. The system operates on the ___________ ______________ ___________________________ principle.

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WS 3.1.2